AN INTERNATIONAL NETWORK
FOR THE IMPROVEMENT OF BANANAS AND PLANTAINS
(INIBAP)

A discussion paper presented by IDRC to a donor group meeting in Rome, May 22, 1984 at 3:30 p.m.

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May 1984

TABLE OF CONTENTS

1. SUMMARY 1

2. INTRODUCTION 4

3. BANANAS AND/OR PLANTAINS 6

4. THE RATIONALE FOR AN INTERNATIONAL PROGRAM 9

5. PRIORITIES FOR RESEARCH 16

6. BANANA BREEDING 26

7. THE WARCORP MODEL 34

8. THE PROPOSED NETWORK 38

AN INTERNATIONAL NETWORK FOR THE IMPROVEMENT OF BANANAS AND PLANTAINS (INIBAP)

1. SUMMARY

1.1 This paper suggests a possible format for an international research network dealing with bananas and plantains, an important group of food crops hitherto largely ignored by the international research community.

1.2 Since most past banana research has been confined to export dessert bananas, it should be stressed that the prime objective of the network proposed in this paper is that of increasing the production and the stability of production of bananas and plantains grown for domestic consumption within the producing countries. This objective would be achieved by:

a) Helping national and regional programs to establish and implement research priorities;

b) Strengthening breeding programs and facilitating the interchange of improved and disease-free genetic material;

c) Assisting in the establishment and analysis of regional and global trials of new and improved cultivars;

d) Supporting studies on banana based farming systems and socio-economics which were associated with the breeding program;

e) Promoting the interchange of documentation and information relating to bananas;

f) Providing appropriate training for staff of national programs; and

g) Identifying donors and assisting countries in the development of proposals for donor support.

1.3 The proposed network would have a regional structure and would focus its support on activities conducted by national research systems (primarily in developing countries). The different regional activities would be linked together by a team of five international coordinators. The approach would be modelled on the successful WARCORP program in West Africa.

1.4 At the global level, it is suggested that the network should not only bring together its own regional activities but should act as a forum to which both developing and developed countries communicated information relating to their national program activities in banana research.

1.5 The network would have a Governance and Program Committee structure analogous to some CGIAR Centres, but would not have a central research facility. It would, however, expect to utilise the resources of existing breeding programs especially the two long established ones (Jamaica and Honduras), both of which have recently started to release their hitherto private germ plasm to the public domain. Evidence exists to suggest that some germ plasm, in at least one of these two programs, possesses resistance to black sigatoka disease, which is causing major losses in a number of areas where bananas/plantains are important subsistence crops. An early goal of the network would be to utilise new tissue culture techniques and hitherto unavailable germ plasm, in order to produce and propagate plants resistant to black sigatoka.

1.6 During the last six months, the proposed network has been discussed and endorsed in principle by four regional consultations attended by representatives of most major banana and plantain producing countries. It has also been reviewed by a scientific advisory panel, who have suggested priorities for the network's research activities.

1.7 This paper proposes an organizational structure for the network and suggests that a Steering Committee be created to establish the governance and organization of the network, with a view to its initial funds being pledged in November 1984 and operations commencing early in 1985.

1.8 The salient features of the proposal are that the network would not involve major capital outlay; it would have a strong germ plasm orientation; most of its research would be done by national institutions; the international staff would be limited to five scientists; and the annual budget (at 1984 prices), would be US$1.6 million at full development (with additional funding, hopefully, being associated with the network through bilateral projects, which it helped to identify and develop).

2. INTRODUCTION

2.1 This paper is the outcome of a request made by a group of donor agency representatives, meeting in Washington on November 1, 1983, at the invitation of IDRC, to consider the topic of research on food (as opposed to export) bananas and plantains. The donor group discussed a short working paper (Appendix 1), prepared by IDRC, which drew attention to a number of recent international meetings which had stressed the need for more emphasis to be given to research on the breeding of food bananas. This need had arisen, not only because breeding offered a possible route for combating black sigatoka disease, which was threatening banana and plantain production in a number of countries, but also because both of the only two major ongoing banana breeding programs faced uncertain futures.

2.2 The working paper indicated that the private agencies controlling both of these breeding programs might be prepared to consider making their germ plasm available world-wide although, in the subsequent discussion, a representative of one of these agencies placed some possible caveats on the availability of their parent material. However, the overall situation did appear to offer a feasible basis for establishing some form of cooperative international activity, with respect to banana and plantain improvement, and IDRC solicited the views of the donor group as to whether and how a cooperative program might be established and implemented.

2.3 The ensuing discussion (Appendix 2) indicated considerable interest on the part of certain donors, although this interest was exclusively in the development of some form of cooperative network, rather than in the creation of a conventional CGIAR-type centre, with a large headquarters research station.

2.4 Against this background, the donor group requested IDRC to undertake further consultations with producing countries, banana specialists and interested donors and to present a more detailed paper, with a formal proposal regarding a cooperative network, at the time of the CGIAR meeting in Rome in May 1984.

2.5 The present paper is the outcome of that request. It has been prepared by an IDRC consultant (Dr. B. Nestel), who accepts responsibility for errors and omissions, but would like to acknowledge the help received from Dr. E. de Langhe (University of Louvain), Drs. J. Champion and J. Ganry (IRFA), Dr. N. W. Simmonds (University of Edinburgh), Dr. A. Ker (IDRC Ottawa), Dr. N. Mateo (IDRC Bogota), Dr. R. Kirkby (IDRC Nairobi), Dr. G. Wilson (IITA), Dr. J. Brown (University of New England) and Dr. G.J. Persley (ACIAR).

3. BANANAS AND/OR PLANTAINS? *

3.1 The use of formal latin binominal nomenclature for bananas is not only confusing but is also misleading. The Linnean species *Musa sapientum* (bananas) is based on a description of the cultivar "silk fig" and *M. paradisiaca* (plantains) on the "French plantain". Both of these "species" are hybrids belonging to what is now designated the AAB group of bananas.

3.2 All edible bananas in the section *Eumusa* (2N = 22 in the wild species) are derived from *Musa acuminata* Colla (AA genome) and/or *Musa balbisiana* Colla (BB genome). Wild, seeded, diploid species of *M. acuminata* had their centre of diversity in the humid tropics of South East Asia (Malaysia to Papua New Guinea). Wild, diploid, seeded species of *M. balbisiana* had a wider distribution and were found in Asia and South East Asia (India, Burma, Thailand, Philippines, etc.). *M. balbisiana* was absent in the areas where *M. acuminata* was most abundant.

3.3 The development of edible bananas initially resulted from man's selection of diploid *M. acuminata* types that were parthenocarpic (production of fruit without pollination) and had female sterility (fruits were seedless). In regions such as Papua New Guinea a large number of edible diploid types of *M. acuminata* are still cultivated.

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* This section is based upon Purseglove, J.W., (1972), The Dicotyledons, Longman, London; Simmonds, N.W., (1966), Bananas, Longman, London; and Brown, J.F., (1984), Bananas in South East Asia and Papua New Guinea, ACIAR, Canberra.

3.4 Triploid forms of M. acuminata (AAA, 3N = 33) were also selected by man. Triploids have larger fruits, are more vigorous, more reproductive and hardier than diploids. The AAA triploids show a wide range of phenotypic variation. In most parts of South East Asia the edible diploids have been replaced by triploid types.

3.5 Cultivars of M. acuminata (AA and AAA) were taken by man to areas where the wild, seeded diploid M. balbisiana were native. Natural hybridization between the two species occurred to produce progeny with the genomes AB, AAB and ABB (Table 1). No edible diploids of M. balbisiana have been recognized.

3.6 The various types of banana, irrespective of their genetic make-up, are often loosely grouped into two main categories, bananas and plantains. There is a lot of confusion in the use of these two terms, especially plantains, where the English usage of the term refers to a certain group of starchy cooking bananas, whilst in Latin America it is sometimes a general collective word for all bananas, irrespective of the character of their ripe fruit. A similar confusion exists in parts of South India where plantains are sweet fruited clones and some bananas are plants that would be called plantains in the West Indian context of the word. In East Africa, a comparable confusion exists because plantains or cooking bananas may be sweet, rather than starchy.

3.7 In order to avoid such confusion in this paper, the term banana is used generically to refer to both groups. When specific reference is made to plaintains it means starchy cooking fruits (even though some of these are locally called bananas).

Table 1: Some Asian banana cultivars and their genome constitution (Brown 1984).

Genome	Cultivars
AA	Only agriculturally significant in Papua New Guinea
BB	No edible types known
AAA	Widespread edible types; several clones recognized e.g. Gros Michel = Pisang ambon = Hom Tong and Cavendish types
AB	Widespread but unimportant e.g. Lady's Finger
AAB	Widespread; important cooking and eating bananas e.g. Latundan = Pisang rastali (dessert banana); French and horn plantains (Pisang tandok); Mysore (most important clone in India); Pisang raja (popular dessert banana)
ABB	Very vigorous and drought resistant e.g. Bluggoe (important cooking banana in many countries), Pisang awak and Saba (common cooking banana in the Philippines).
AAAB	Rare but reported in New Britain e.g. Atan and Kudu-kudu
AABB	Rare but reported in Bougainville e.g. Kalamagol

4. THE RATIONALE FOR AN INTERNATIONAL PROGRAM

4.1 Bananas and plantains are important carbohydrate food crops in many tropical countries. Current world production is estimated at over 62 million tonnes, of which about 19 million are grown in Africa, with Uganda, Nigeria, Rwanda and Zaire the largest producers. Sixteen million tonnes are grown in Asia, with India, the Philippines, Thailand, Sri Lanka and Indonesia predominating. Sixteen million tonnes come from South America with Brazil by far the largest producer in the world, followed by Ecuador and Colombia, and 9 million tonnes from Central America and the Caribbean where Mexico and Honduras are the biggest producers (see Appendix 3). Since the world export trade in bananas is only about 7 million tonnes, it is clear that the crop is far more important globally as a food crop for local consumption than it is as an export commodity.

4.2 Currently, about half of the bananas consumed are eaten raw and ripe, and the residue are eaten as a cooked vegetable. Dessert bananas are sugary, easily digestible and eaten raw. Cooking bananas are either dessert bananas cooked while still unripe, before the starch has been converted to sugar, or cultivars that possess a high starch content when ripe.

4.3 In North America and Western Europe banana consumption averages 10-30 grams/head/day or up to one banana a week. In some African countries where bananas are a staple diet, average national daily consumption may exceed 0.5 kg, with daily intakes providing between 300 and 600 calories. Such average figures mask local differences and some African rural communities obtain around half of their total calorie intake from bananas. At the global level, bananas and plantains are the thirteenth most important crop in calorie terms and the fifteenth in terms of protein. A recent TAC paper (Piñeiro 1984), notes that they represent a major gap in the CGIAR coverage of food crops.

4.4 It is difficult to determine the farm gate value of the crop. The only readily available data relate to the 11% of total production that enters the world export trade. Average import and export prices for bananas traded internationally in the years 1978-1980 were as follows (FAO Trade Yearbook):

	Average Price (US$ per tonne)	
	Exported	Imported
1978	150	257
1979	168	283
1980	182	319

4.5 More recently a survey amongst Latin American and Caribbean countries has indicated farm gate prices ranging from 10 to 20 US¢/kg. and averaging about 15¢. If these prices are in any way indicative of the global situation the total farm value for world production will be in the order of US$10 billion per annum. The importance of bananas/plantains in an individual economy is illustrated by the example of Colombia where the total farm gate value of the crop in 1983 exceeded that of rice and was equivalent to 50% of the value of coffee.

4.6 Information about the costs of research on bananas is not readily available. The figures in Appendix 6 imply an annual research input of about US$6 million (0.06% of the value of production), much of which is provided by a small number of countries exporting dessert bananas or mounting major disease control programs (with spraying costs sometimes allocated as research). Inputs to plant breeding are very limited with only Honduras and Brazil appearing to have an experienced plant breeder working full time on the crop. Only in the last few years has any serious breeding work been done on plantains.

4.7 Cultivated plantains and bananas are always propagated clonally, and most of them contain very few or no seeds, which would make them unpalatable. Like other clonally propagated crops, this means that all the plants of one cultivar are genetically identical and are therefore equally susceptible to particular pests or diseases. This can be very dangerous, as is illustrated by the fact that in the early years of the twentieth century the world banana trade was entirely dependent upon the Gros Michel cultivar. This proved to be highly susceptible to Panama disease, caused by the fungus *Fusarium oxysporum f. cubense*. This disease gradually spread through the main banana exporting areas in Latin America and the Caribbean and virtually eliminated the use of the Gros Michel cultivar which was eventually replaced by the Cavendish cultivar, which, although less suitable for the export trade, is highly resistant to both of the common strains of Panama disease. This resistance now appears to be under challenge by a new type of Panama disease which has appeared in South Africa, Australia, the Philippines, Taiwan and elsewhere.

4.8 Another important disease of the crop is bunchy top (an aphid-borne disease presumed to be caused by a virus) which is widespread in Africa, Asia and the Pacific but apparently absent in the Western Hemisphere. It can cause serious losses and its incidence appears to be increasing in some countries, such as the Philippines, where it is believed that wild bananas act as sources of innoculum of the virus, which subsequently affects plantation crops. In Africa the disease is surprisingly sporadic in its distribution and some cultivars appear more tolerant than others. There is an urgent need to develop a rapid indexing method for this disease, so that certified disease-free planting material can be made available.

4.9 Plantains and bananas are attacked by a number of other serious diseases and pests, of which some of the most important are yellow leaf spot or sigatoka and burrowing nematode (Radophilus similis). However, although these cause serious damage to some cultivars, they can be controlled with appropriate fungicide and pesticide applications, but these are often difficult to apply on a regular basis on small farms unless these is some form of coordinated disease control program.

4.10 In recent years, a form of leaf spot named black sigatoka (Mycosphaerella fijiensis var difformis) has appeared and is causing severe damage to many plantain and banana cultivars in Central America and elsewhere. It can be kept under some sort of control by frequent fungicide applications, but these are only practical on large plantations producing high yields. Annual control costs are US$800-1,500 per ha, such costs exceed the cash available to small growers. In Central America, it is estimated that black sigatoka control costs US$100 million per annum.

4.11 Black sigatoka was first reported in Fiji in 1964 and since the early 1970's has spread through a considerable part of Central America and Colombia. It has caused serious losses in the important plantain crop which was a staple food for many smallholders in this region. In some areas production has been virtually eliminated, for example plantain exports from Honduras which were 500,000 boxes a year, a few years ago, have now fallen to zero. Most plantain and banana cultivars appear to be susceptible to this disease, but one group, including the cultivars Saba, Pelipita and Bluggo appears to be tolerant. Saba is widely used as a cooking banana in the Philippines, although it is of a type that is not usually consumed in Latin America.

4.12 Black sigatoka has been identified in Gabon in West Africa and has since spread into Cameroon and Congo and more recently in Northern Zambia. It has already caused severe damage to the important plantain crop, which is a staple food in Gabon and several other West African countries.

4.13 In July 1981, the International Association for Research for Plantains and Other Cooking Bananas (IARPCB) conference at IITA, Nigeria, recommended urgent action to combat the worst effects of the disease. Since black sigatoka is windborne, it can be expected to spread through the plantain and banana growing areas of the world, although its rate of spread is unpredictable. The conference recommended that immediate action be taken to multiply those varieties, thought to be resistant, including Saba, Bluggo and Pelipita, to arrange distribution of these to affected areas and to organize testing for resistance. In addition, other possible resistant material should be introduced and tested as rapidly as possible, giving due care and attention to plant quarantine regulations.

4.14 Since the number of resistant cultivars appears likely to be very limited, the conference also recommended that breeding for resistance should be undertaken as rapidly as possible.

4.15 In July 1982, a small group of plantain and banana specialists met at the International Development Research Centre (IDRC) headquarters in Ottawa, Canada, to plan for the formation of an international plantain/banana improvement program which would assist in implementing the IARPCB recommendations. There was unanimous agreement amongst those present that urgent action was needed to establish an informal international network, linking national plantain and banana research organizations, in order to strengthen these organizations and to encourage the safe exchange of plantain and banana germ plasm, using meristem culture techniques, so that disease-resistant planting material could be made available.

4.16 Similar views have been reiterated and expanded upon at a series of regional consultations carried out in East and West Africa, Latin America and South East Asia during the last six months (Appendix 7). This paper is a response to these consultations and discusses the formation and structure of the proposed network.

4.17 An important aspect of the network's activities would be to capitalize on the broad range of germ plasm in existing collections, especially those in Honduras and Jamaica. This could eventually be expected to lead to the provision of new disease-resistant material of both plantains and bananas, and this could be tested and distributed to those countries affected by black sigatoka or other diseases (particularly the new race of Panama disease) for further testing and distribution. The prospects for doing this are excellent, since some of the new Jamaican tetraploids, which give high yields (but whose poor shipping quality militates against their use as export dessert bananas), have recently been shown in tests in the Cook Islands to have a high level of resistance to black sigatoka.

4.18 The general objective of the proposed network would thus be to improve the production and quality of plantains and bananas as major foods acceptable to smallholders and consumers in the developing countries of the tropics. The more specific objectives would be to:

a) Select and develop plantain and banana material resistant to the major diseases and pests of the crops;

b) Subject this material to a program of regional trials prior to disseminating promising cultivars to interested countries; and

c) Establish a global network which would link and strengthen national and international plantain/banana improvement programs.

5. PRIORITIES FOR RESEARCH

5.1 The three major components characterizing the research activities of CGIAR centres are breeding, husbandry and socio-economics. In the case of bananas, a meeting of specialists convened by IDRC in December 1983 (Appendix 4) suggested that husbandry and socio-economic work was so location-specific that the primary thrust of any international banana network should be associated with breeding, screening and selection activities.

PLANT BREEDING

5.2 The starting point of any breeding strategy is usually the collection of germ plasm. According to the report of the first meeting of the working group on bananas of the International Bureau of Plant Genetic Resources (IBPGR) held in Rome in 1977, there are only five major banana germ plasm collections in the world. These are located in Honduras, Jamaica, the Philippines, Papua New Guinea and India. Since that date, a number of smaller, local collections have been expanded, for example in Brazil, Guadeloupe, Nicaragua, CATIE (Costa Rica), the Cameroons, Thailand, Malaysia, Indonesia, and at IITA in Nigeria. Although the number of collections is still quite modest, it appears that some of them are quite comprehensive and the need for seeking additional germ plasm, possibly before it is irretrievably lost, relates mainly to collecting material from Kampuchea, Vietnam*, Burma and possible Northern Malaysia, with the remoter parts of Papua New Guinea, the Philippines, and Indonesia as lower priorities. For plantains (or starchy cooking bananas), the IPBGR has identified the collection in

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* Some Vietnamese material was recently obtained by Nicaragua and is being evaluated at CATIE

Ekona (Cameroons), as being of importance and has recognized the need for limited additional collecting in South East Cameroons, South Gabon, Congo Brazzaville, and Zaire. Recently, the most promising plantain cultivars from Honduras and Papua New Guinea were brought to Costa Rica (CATIE), using tissue culture techniques, in order to evaluate this material against black sigatoka under field conditions in Central America.

5.3 The IDRC-invited specialist group thought that collection is best left to the IBPGR and should not be a function of the proposed network. However, at the national level the establishment of working collections is a basic priority. There is also a need for regional working collections containing, selectively, the best germ plasm from local and national collections but with some representation, also, from the international collections. Regional collections exist at Davao in the Philippines, Ekona in West Africa and a small one in the Windward Islands (WINBAN) and these will no doubt prove to be valuable sources of material in the future. Other collections need to be established, and in this respect Asia and Africa justify a higher priority than the Western hemisphere, since banana germ plasm is much more diverse in Africa and Asia than it is in the Americas.

5.4 Indeed the importance of bananas and plantains in all three major continents suggests that there should be at least one major centre of germ plasm improvement in each of them and that a global network should not rely entirely on tropical America as its sole source for genetic improvement. Thus, there may be a good case for international support for developing breeding programs in selected African and Asian locations.

5.5 The group thought, however, that the core of an international breeding program would need to be located in the American tropics because of the absence there of bunchy top disease and because of the presence there of long-established breeding sites

(Jamaica and Honduras). But for the programs in these latter two locations to play an important role internationally, it would be essential for them to permit their breeding material at any stage of development to be freely available to any country participating in the network. <u>There could be no qualification of the principle of freedom of genetic exchanges</u>.

5.6 The first important stage in any international effort should be to screen the existing germ plasm, particularly the improved material in Honduras and Jamaica, which has been evaluated primarily in those two countries, in terms of its potential as an export dessert banana. Even in these countries, the new triploids and tetraploids, which have been bred, do not appear to have been extensively screened for use as non-export food bananas, although there is some evidence that the new tetraploids, in particular, are of interest through their resistance to Panama disease, leaf spot and nematodes. Four new Jamaican tetraploids are now undergoing farm trials and two are being looked at for black sigatoka resistance in the Philippines.

5.7 However, it is not just in Honduras and Jamaica that existing germ plasm needs to be carefully examined and evaluated. For example, the Papua New Guinea collection at Laloki has 234 accessions of which 35 clones, including 15 AA diploids are reputed to show low levels of susceptibility to black sigatoka. The Philippine collection has 180 accessions from the Philippines, Thailand and Malaysia; the Malaysian collection had 128 accessions in 1980 and has since been added to, in Brazil the national collection has 124 accessions from a wide range of sources. The several smaller collections in Indonesia are reputed not to reflect the wealth of <u>Musa</u> germ plasm readily available in that country. So a key early task for an international program is to describe and evaluate this existing germ plasm.

5.8 The Honduran and Jamaican collections, as well as a number of others, are know to contain cultivars with the balbisiana (B) genome, which is found in a number of important cooking bananas. B genomes tend to confer hardiness and disease resistance as well as cooking qualities, but little has been done in the way of breeding balbisiana until very recently. For doing this, the synthetic male AA parent diploids appear to have just as major a role to play as they do with export dessert bananas.

5.9 Another aspect of balbisiana breeding that may be of great interest is the introduction of dwarf mutants, and a study of their breeding and physiological characteristics. It is possible that dwarfs are morpho-physiologically more efficient, as well as being wind resistant and easier to harvest. Some dwarfs and semi-dwarf mutants of acuminata are well known but a detailed study of dwarfing and its induction in balbisiana could be very important.

5.10 The need for screening existing balbisiana germ plasm is not confined to Jamaica and Honduras. For example, the starchy ABB's grown in the Philippines and held in the collection at Davao could be important in the control of black sigatoka in Gabon and need to be incorporated into the African regional collection at Ekone.

5.11 The key objective of the breeding program should be to breed bananas as a local food, which implies that the products must be genetically diverse. Some crosses appropriate to this objective might produce clones worth consideration for the export trade, but this objective should be strictly subsidiary. The breeding program should use, not only established techniques, but should maintain an open mind about the use of new methods and should have associated with it a strong meristem culture activity to facilitate the international distribution of banana germ plasm.

5.12 Whilst the key role that Honduras and Jamaica could play in the early stages of a cooperative effort has been noted, it is also recognized that several national programs have already started or might undertake breeding activites in the future; such action would initially be complementary to that undertaken by countries with longstanding breeding programs with a very broad genetic base. Newer programs could not substitute quickly for those that were well established but could benefit considerably from being closely linked with them.

5.13 Because most bananas and plantains are grown on small farms, the specialist group thought that the IARC model of uniform regional trials was both impractical and unrealistic for banana work. Evaluation work on bananas would need to be conducted on the basis of on-farm trials under mixed cropping, with the evaluation of the variety under test being based on its local utility in the small farm context.

5.14 Apart from the conventional approach to breeding, consideration also needs to be given to looking at potentially faster breeding methods, such as through induced mutation or through somatic hybridization. Such work might be carried out, at least initially, in developed country laboratories with special facilities and expertise in this kind of work. Scientists in the State University of New York are at the forefront of this field and have claimed success in producing somatic embryos from triploid plantains.

5.15 The field of meristem culture would appear to have particularly important prospects in germ plasm evaluation, through both facilitating propagation and reducing disease risks from the movement of plant material. Meristem culture of bananas has been studied extensively in Louvain, Belgium and also in Florida and elsewhere and techniques have been developed that can be successfully used for rapid multiplication. Further work needs to be done on developing techniques to use meristem culture for disease-indexing through the use of biochemical techniques. In the broad field of tissue culture, it would also be of considerable value were a technique to be developed which would permit cryopreservation for the long term conservation of genetic material.

5.16 Another important task relating to plant breeding is the need to identify and adequately describe germ plasm. A descriptor treatise on clones has recently been published by the IBPGR and needs to be widely used, so that the material in existing collections can be recorded and compared.

5.17 The specialist group thought that a good general knowledge of existing clones was fundamental and that, in most banana producing countries, such knowledge did not exist. The description of clonal material was confused by the complexities of nomenclature, the same clone often being known by several different names within one country. The situation would be eased by the wider use of the descriptor list. This list, although designed for a slightly different purpose, could readily be adapted to local identification and listing.

CROP AGRONOMY AND FARMING SYSTEMS

5.18 There is, perhaps, more knowledge of the role of bananas and plantains in agricultural systems than there is about the banana germ plasm available. However, this understanding tends to be very location-specific. Where bananas are grown in monoculture for export markets, knowledge of husbandry is excellent but this is seldom true when the crop is grown in backyard systems, or as a major component of more extensive food cropping complexes.

5.19 It is difficult to differentiate between the role of bananas in an agricultural system and their role in a particular culture. The local importance of the crop relates closely to the degree to which that society is dependent upon it. In some cultures, the banana is an optional dietary component but, in other, it is a major source of dietary calories. In societies highly dependent upon the banana, there usually appear to be quality preferences; current knowledge, about both the rationale of these practices and the physiological factors which determine quality, is sparse.

5.20 Similar considerations apply to research on crop agronomy. The husbandry features of the commercial crop are well enough understood but small farmer problems and methods are highly location-specific. There does not appear to be a case for international research in this area. A case can, however, be made for conducting work on crop physiology at a specific research station, since such work could be globally relevant. A similar consideration applies to fruit physiology where there is an urgent need to develop clear criteria for characterizing varieties by their quality features, specifically their starch, sugar and acid contents during ripening. Such work would be relevant to the understanding of the utilisation, storage and post-harvest management of different cultivars.

5.21 There are many pests and diseases that affect the crop; some of them are already serious and some others have the potential to become so. The disease picture in general appears to be changing, with some diseases that were unimportant several years ago now becoming very significant. This highlights the danger of over-dependence on a limited number of clones, and stresses the need for developing a broad range of widely adapted genetic material.

5.22 However, a great deal is already known about the pests and diseases of bananas and there is a standard work on banana diseases. Many pests and diseases can be (more or less) controlled by chemicals, but the use of these on small farms is generally impractical on grounds of costs. In the long term, genetic resistance to pests and diseases will be necessary, supplemented by good husbandry. The main role of pathology research lies in disease-indexing to facilitate safe transmission of clonal materials, but there will also be some *ad hoc* need for research on new disease/insect problems, if and when they arise.

SOCIO-ECONOMICS

5.23 With regard to socio-economic research, the specialist group thought that this came into the same category as crop husbandry and uniform regional trial activities, it belonged with on-farm research and should be a component of national programs, rather than of any central core activity. It is, however, an area in which only a limited amount of work appears to have been done. An expanded international program of breeding and screening new cultivars will need to go hand-in-hand with studies on consumer acceptability and factors incluencing this characteristic in cultivars new to an area. The criteria of how to determine acceptability and how to modify cultural preferences are topics that would appear to present interesting challenges to social science researchers.

POST HARVEST RESEARCH

5.24 The specialist group felt that post-harvest research should not be a high priority for the network as a whole. They recognized that it was a high priority for some exporting countries, where this type of research will obviously be of importance, but felt that such work was best supported on a bilateral basis as it concerned a limited number of countries. There would obviously be some merit in informing the network about such work, although the network itself should not be heavily involved in it, at least initially. However, this view was challenged in the Latin American consultation, with its admittedly strong export group, who felt that the wastage in reject bananas was of such a large magnitude that it justified a major research effort on alternative usage.

INFORMATION AND DOCUMENTATION

5.25 There appear to be at least two current services which provide specific documentation on bananas and plantains. One is the longstanding abstract service of IRFA and the other is a rather newer program at UPEB, supported by IDRC. Although there are some linkages between the two programs it is possible that some duplication exists. Duplication may also occur with the abstract services provided by the Commonwealth Agricultural Bureau (CAB), the Royal Tropical Institute in Amsterdam, AGRIS, WINBAN and IITA. However, there appear to be many gaps in the collection of non-formal literature and a need appears to exist for a dialogue between the various information specialists. Both IRFA and the information division of IDRC are sympathetic to convening a specialist meeting on this subject with a view to discussing how a CGIAR type Documentation Centre for bananas might be established, should the present meeting decide to proceed further with discussions on an international network.

TRAINING

5.26 The specialist group thought that there was an important need for IARC-type production training at a fairly basic level, that this should be regionally-based and that it should be an important component of the developing regional networks. To make such a suggestion workable, each of the regional networks would need to have a central, focal point where such training could be carried out. At present, this is only possible in Africa, through the activities of IITA. The group thought that the provision of basic banana production training would be the best way to help to develop national capabilities to cope with the problems of clonal exploitation and agri-social systems, identified above as being of high priority.

5.27 This production training should be brought into the regional networks very early in their existence. Later, there would be a need for more specialized, higher level, training to provide scientists in national programs with expertise in particular topics, such as shoot-tip culture and breeding. This, too, would require a central training facility, such as might be found in an IARC or a large national program.

6. BANANA BREEDING

6.1 The core of any proposed network would be its selection and breeding activities. Since banana breeding possesses some rather unique features, which are not widely known, it would appear relevant to comment on these at this point.

6.2 Most edible bananas and plantains are derived from two wild species *Musa acuminata* (AA genome) and *Musa balbisiana* (BB). These species have given rise to eight groups of clones, two are derived solely from *M. acuminata* (AA, AAA), the remaining six contain genes from both species (AAB, ABB, AB, ABBB, AAAB, AABB - the last three of which are rare and unimportant).

6.3 In addition to the genus *Musa*, there is a sub-genus of edible bananas known as *Australimusa*, which contains the Abaca plant and the red juiced erect fruited Fe'i banana, which is found from Eastern Indonesia to the Marquesa Islands. The botany of this localized group of bananas is poorly understood, although they are of some importance as a food crop in some of the Pacific Islands, but in overall terms they are very much less important that the *Musa* group.

6.4 The major problems of *Musa* breeding are:

a) The popular cultivars are usually highly sterile triploids;
b) Seed set and germination are low;
c) The tetraploids resulting from the diploid - triploid crosses produce large numbers of weak seedlings;
d) Synthetic males, in which undesirable traits have been bred out and desirable resistance bred in, require many years for development (a three-year generation interval on the average);
e) Plantain, the important cultivar in Africa, has never produced viable seed and direct hybridizations may be impossible;

f) In-vitro propagation with small apical meristem pieces is possible; but single cell totipotency, essential for somatic fusion by genetic engineering, has not been achieved.*

g) Certain basic requirements such as Fusarium sp. nurseries must be available; and

h) The location must be free of virus, and possibly bacterial, diseases that are transmitted in vegetative propagules.

6.5 Banana breeding started in 1922 at the Imperial College of Tropical Agricultural in Trinidad and in 1924 in Jamaica. These two programs became a cooperative project and in the 1930's fundamental botanical studies were carried out in Trinidad, while practical breeding operations were done in Jamaica. After 1960 this breeding scheme was continued only in Jamaica, where it is maintained at present, although at a very low level of activity. In Honduras, the United Fruit Company began an extensive breeding program in 1959, after abandoning brief efforts at breeding about thirty years earlier.

6.6 Both of the above breeding programs have focussed primarily on export dessert bananas and have attempted to improve the only two wild clones (Gros Michel and Cavendish) which have been acceptable to the export trades. But despite almost sixty years of breeding work, no new banana cultivar has been bred which is commercially acceptable as an export crop.

6.7 Both the Jamaican and Honduran programs have good collections of wild material and are in areas that are free from bunchy top disease, which is prevalent in much of Africa and Asia. The Jamaican program, which commenced with Meso-American material, carried out collections in East Africa in the late 1940's and in

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* However, there is a very recent claim that somatic embryos can be formed in plantains.

South East Asia and the Pacific in the mid-1950's. The Honduran collection, which was originally based on Caribbean and Central American material, was added to the 1920's by material from South and South East Asia and Oceania and by further collections in these areas in 1959-61. It now contains 474 entries with four plants of each. More limited collections now also exist in India, the Philippines, Papua New Guinea, Taiwan, Brazil and Guadeloupe and breeding programs are underway in India, Taiwan, and Brazil, and one is now being established in Guadeloupe.

6.8 The fundamental work in Trinidad and Jamaica established the basic principles of banana breeding. Near commercial-type hybrids were produced by crossing wild seeded M. acuminata on to Gros Michel. Cytological studies had shown that Gros Michel is triploid (AAA), and M. acuminata diploid (AA). Most progenies from this cross are tetraploids. Gros Michel contributes an unreduced triploid gamete to the combination, which results in tetraploid offspring with pronounced Gros Michel features. A small percentage of heptaploids are also produced from the cross, due to double restitution of the Gros Michel gamete. These heptaploids are thick leaved dwarfs, which grow slowly and never flower.

6.9 The genetic abnormality of Gros Michel in contributing unreduced egg cells, instead of undergoing normal meiosis, during sexual reproduction is what makes practical banana breeding possible. The only other triploid clones which could possibly be used as female parents are the Cavendish group. But these are highly sterile and no viable seeds have been produced, after extensive pollination, nor have any other suitable parents been identified to date.

6.10 Early attempts to use the primary tetraploids derived from Gros Michel, in subsequent crosses with other tetraploids and diploids, resulted in inferior progenies. Secondary tetraploids and triploids were produced but none approached the commercial acceptability of the primary tetraploid. The reason for this appears to be that the secondary tetraploids and triploids were the products of meioses in which the Gros Michel chromosomes had participated. This breakdown of the highly selected and desirable Gros Michel combination accounted for the generally unpromising nature of the polyploid progenies.

6.11 It appears that progress in banana breeding using conventional practices depends upon breeding new diploid male parents and then seeking commercial bananas among the primary tetraploid progenies from crosses on to Gros Michel. Highgate, a dwarf mutant of Gros Michel, which produces progeny less prone to wind damage has now become the standard female parent, rather than Gros Michel itself. But all advances are still dependent upon development of improved diploid pollen parents.

6.12 One weakness of this classic approach to banana breeding is that the Gros Michel dwarf mutants are fixed as seed parents and this restricts genetic diversity in the resultant hybrids. This is compensated for by the many desirable features of the Gros Michel type: better resistance to fruit bruising and scarring; less susceptibility to chilling injury; vigorous growth habit; and excellent quality. To avoid the dangers inherent in closely related cultivars, however, more diverse polyploid seed parents are desirable than are obtainable by the classical breeding method.

6.13 A potentially feasible method of broadening the genetic base of commercial type tetraploids is by making tetraploid-diploid crosses and then selecting seeded triploids for further crosses. If such triploids would contribute unreduced egg cells when crossed with diploids, the resultant tetraploids would have three introductions of diploid parents and would be quite different genetically from the original Gros Michel type parent. This method of breeding more diverse tetraploid clones is currently under investigation in Honduras.

6.14 However, even with this, the prospects for breeding improvement lie mainly through developing superior diploid male parents. In many respects, these prospects are promising, since sources of genetic resistance to the major banana diseases are readily identifiable in the diploid collections in both Jamaica and Honduras. However, there is a shortage of fertile dwarf diploids with combinations of good agronomic qualities. The recently developed superior diploids are being utilised in two breeding schemes. In the first, dwarf mutants of Gros Michel are used as the female parent for breeding superior tetraploids. In the second, tetraploids that produce seed are pollinated by advanced diploids to produce triploids, which are then screened for desirable agronomic characteristics, including dwarfism. Both schemes appear to have potential when improved diploid male parents are used. In Jamaica, testing of some of the new tetraploids has shown that their yields are superior to the standard Cavendish clone. However, although their flavour is acceptable, in general, the newer tetraploids have shorter storage periods, softer pulp and weaker pedicels, resulting in premature detachment of individual ripe fruit from the crown. It is possible that these disadvantages (which mainly affect export fruit), can be overcome, since diploid parents do exist with longer green life, firmer pulp and stronger 'necks' which prevent 'finger drop', and these characteristics appear to be genetically controlled.

6.15 Triploids may have advantages over tetraploids as commercial hybrids, as it is claimed that higher levels of disease resistance can be bred into hybrids by using diploids as parents twice in the tetraploid-diploid breeding program. Also, triploids are reputed to retain their leaves longer than tetraploids without the premature petiole breakage, common in tetraploids.

6.16 A further method of genetic manipulation is to induce somatic mutations in the Cavendish clones and to examine the mutants for disease resistance and other desirable characteristics. The successful culturing of meristems in nutrient media has greatly facilitated further exploration of this potential source of genetic variation, and it has been tried over the last decade in both Jamaica and Honduras and, more recently in Costa Rica (CATIE).

6.17 Nearly all past efforts at breeding have been devoted to dessert bananas, which are pure M. acuminata, whereas plantains and other cooking bananas are hybrids between M. acuminata and M. balbisiana. In taxonomic shorthand, the cooking bananas are classified as AAB and ABB to depict ploidy and genomic constitution in terms of the two parental species.

6.18 The most widely grown cooking banana in Central and South America is Horn Plantain (AAB). This is resistant to yellow sigatoka but is susceptible to black sigatoka, which threatens the continued cultivation of this important cultivar.

6.19 Horn plantain is sterile, however, the AAB Lacknau which closely resembles it, does produce a few seeds per bunch when pollinated. Lacknau, like Gros Michel, produces some unreduced egg cells during sexual reproduction, and the tetraploid progenies from crosses with AA diploids have bunch characteristics similar to Lacknau. Unfortunately, the cooking quality of Lacknau and its hybrids is inferior to those of Horn plantains, however, Lacknau is reputed to show some resistance to black sigatoka.

6.20 Several ABB clones are female fertile and some produce normal triploid and tetraploid hybrids when pollinated with AA diploids. These clones and their hybrids have better cooking qualities than Lacknau, but produce short, angular fruits.

6.21 The ABB clones, Chato, Pelipita and Saba have good levels of tolerance to black sigatoka. Chato has excellent cooking qualities, but is susceptible to bacterial wilt or Moko disease (Pseudomonas solanacearum), and race 2 of Fusarial wilt. Pelipita is resistant to bacterial and fusarial wilts, but has not been widely accepted for organoleptic reasons. Saba has shown field resistance to both bacterial and fusarial wilts and is a favoured cooking banana in the Philippines. This clone is being distributed to areas affected by black sigatoka, as a possible substitute for Horn plantain.

6.22 In the meantime, the advanced diploids, which are being bred for the synthesis of commercial-type dessert bananas are also being explored in Honduras for their usefulness in crossing for dwarf disease-resistant cooking bananas. Cross-pollinations between progenies from Lacknau and seed fertile progenies from the ABB clones are scheduled, in an attempt to combine the fruit shaped characteristics of Lacknau with the cooking qualities and black sigatoka resistance of the ABB types.

6.23 All of this work on plantains is of very recent origin and has only just been made available to the public sector. Given the knowledge and background that exists in breeding dessert bananas, and the progress that has been made with male diploids there, it does seem that opportunities now exist for making good progress in improving both disease resistance and yield in plantains and other cooking bananas.

6.24 These prospects are enhanced by two facts. First, talks are now underway to explore the possibility of rehabilitating the breeding program in Jamaica which, through shortage of funds, has been on a 'care and maintenance' basis only for several years. Second, the Honduras program and collection of the United Brands Company was made over to the Honduran Government at the beginning of 1984. It is currently funded for six months by FAO whose support may be extended further, but is ultimately expected to be taken over by USAID who have recently approved a preliminary plan aimed at providing secure funding for a ten-year period for a Honduran Research Foundation whose mandate would include all types of bananas. The Jamaican and Honduran programs are of considerable importance, in the uniqueness of the germ plasm which they contain and should, clearly, play a vital role in any international banana breeding activity.

7. WARCORP

7.1 The West African Regional Cooperative for Research on Plantains (WARCORP), sponsored by IITA and funded by IFAD, provides a useful model for a research cooperation network with Musa. WARCORP coordinates the activities of scientists engaged in research on plantains in West Africa. Each active scientist receives a grant to carry out one experiment. These experiments are decided on at the cooperative's annual meeting, which rotates between countries. Grants are allocated on the following basis:

a) The interest and specialization of the scientist;
b) The priorities of the region or country;
c) The priorities of the cooperative; and
d) The availability of funds.

7.2 At each meeting, the scientists present report on all experiments supported by the cooperative and also on related work in the region supported by other sources. Each scientist receiving funds from the cooperative is allowed approximately one hour for the presentation and discussion of his results. The discussions on these results and on proposals for funding, facilitate interdisciplinary interaction, create better understanding of problems, reduce repetition and duplication and enhance confidence and competence.

7.3 Experiments currently underway are:

i) Tissue culture (Ivory Coast);
ii) Off-season production (Ivory Coast);
iii) Sink source relationships (Ghana);
iv) Weed control (Nigeria);
v) Economics of backyard or compound production (Nigeria);
vi) Effects of sawdust mulch (Nigeria);

vii) Bibliography on methods of preparing plantain/banana chips (Nigeria);

viii) Effects of water hyacinth mulch (Zaire);

ix) Cultivar reaction to black sigatoka and its control by fungicidal sprays (Gabon);

x) Mulch source proximity (IITA);

xi) Effects of mulch and fertilizer (IITA); and

xii) Development of rapid multiplication techniques (IITA).

7.4 In addition to supporting research in the national research centres, WARCORP is also active in the fields of training and in providing disease-free planting material. Training comprises various types of production training at IITA. The latest production systems training course lasted four weeks in 1983 and had 19 trainees coming from Sierre Leone, Guinea, Senegal, Ivory Coast, Ghana, Nigeria, Cameroon, Uganda, Burundi, and IRAZ (Burundi/Rwanda/Zaire). In addition, early in 1983, a one-month training course was set up at IITA's plantain tissue culture laboratory, to train six scientists from the Ivory Coast, Nigeria, Cameroon, and Kenya in meristem culture techniques. The countries where these scientists are located, now have the potential capability to produce and handle banana planting material in tissue culture form. To do this they use a technique developed in Belgium which is appropriate for both rapid multiplication and germ plasm exchange.

7.5 It is anticipated that through the use of tissue culture of indexed material which is passaged through an intermediate laboratory in a non-banana producing area (such as Louvain in Belgium or Montpellier in France), it will be possible to ship banana germ plasm from country to country without incurring disease risks. However, this process may well be simplified in the future if appropriate techniques of disease-indexing can be developed and tissue culture facilities become more widespread.

7.6 Germ plasm exchange, the evaluation of new germ plasm and a selection of agronomic research are all activities carried out by the WARCORP network coordinator in addition to his training role and his advisory inputs to the national programs. The organization and activities of WARCORP are shown schematically in Figure 1. There appear to be a number of features of this model that are relevant to a global approach, namely:

1. There is a minimal capital outlay;
2. Most of the research is conducted by national institutes; and
3. The network coordinator is located at an institute that is particularly well equipped for training and tissue culture activities.

7.7. This approach would be considerably strengthened were it to be linked to a strong breeding program and a good information and documentation system. Such breeding and information activities could, however, serve more than one regional network at marginal extra cost, hence the concept brought forward in the next section of this paper, concerning a global network containing a series of regional components.

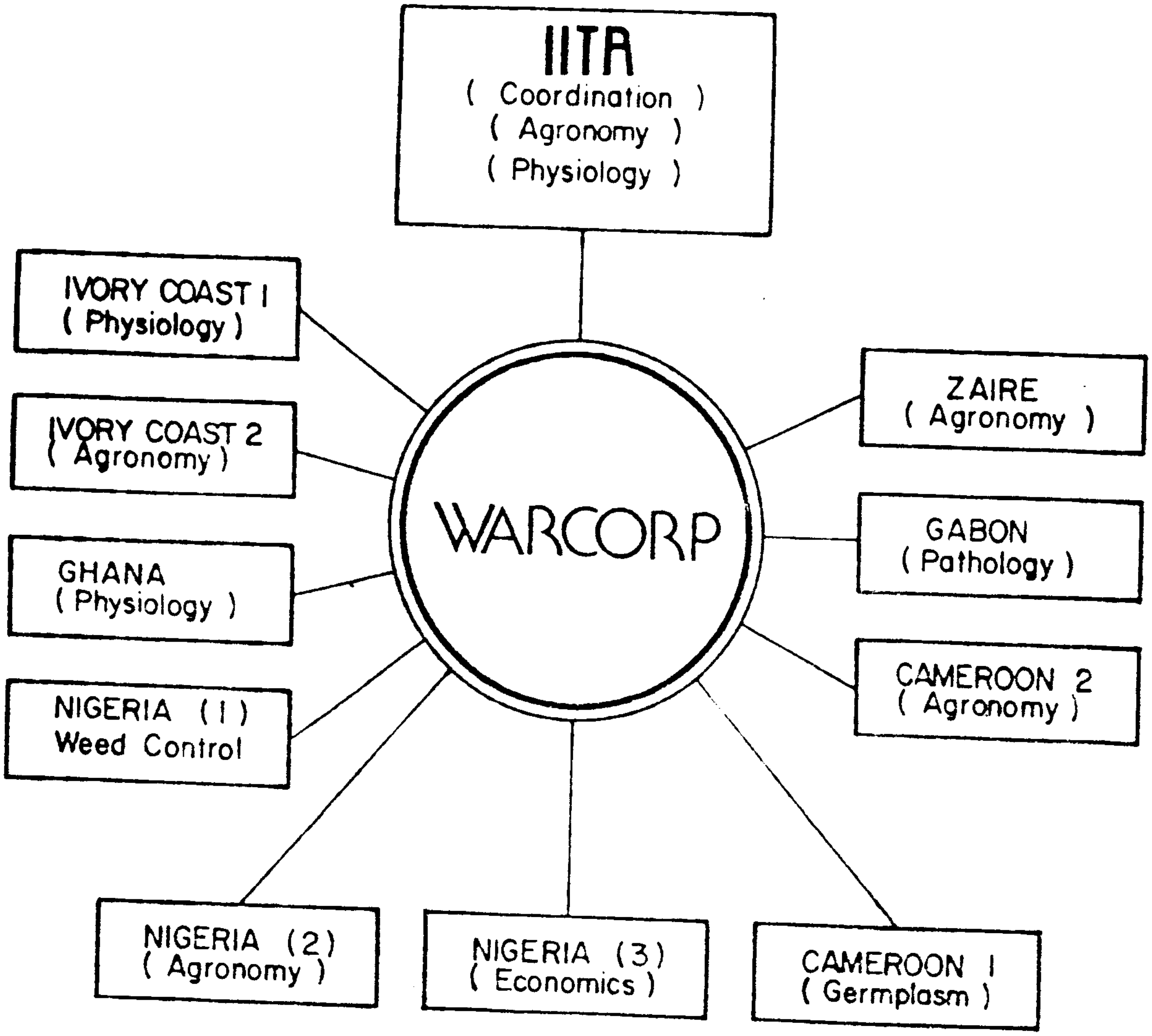

Fig. 1 Organization and activities of West African Regional Cooperative for Research on Plantain. (WARCORP)

8. THE PROPOSED NETWORK

8.1 Should the donor group, meeting in Rome on May 22, 1984, decide to proceed further with this proposal for a banana network, then it is recommended that a small Steering Committee be established, comprising of representatives of donor agencies with a firm interest in supporting the network and representatives of banada producing countries. This Steering Committee would be responsible for reporting to the main group in Washington, in November 1984, regarding final proposals for the organization, management and budget of the network and for selecting the initial Board, Director and headquarters location. Preliminary suggestions on all of these topics are offered below, based on discussions with donors and producing countries, during the last six months.

THE BOARD OF GOVERNORS

8.2 The Board will be the executive and policy-making body with primary responsibility for the network (INIBAP). It will comprise 8-16 members, plus the Director as an *ex-officio* member. Half of the Board will consist of representatives from the donor group and the other half will be from banana producing countries, with at least one member coming from each group of countries served by each of the operational regional networks. The Board will meet once a year and will appoint an Executive Committee of three to five members to act for it between meetings. The selection of the initial Board will be an early task of the proposed Steering Committee.

8.3 The Steering Committee will also need to decide on the following points, on which the Board structure could differ from the usual CGIAR format:

a) Does the Board necessarily need an *ex-officio* host country representative from its headquarters location, when that location is primarily an administrative seat? This may depend on the charter of the network (see later)

b) Is is necessary to restrict the terms of Board members to a certain duration (e.g. six years) or would it be desirable to have a mechanism whereby the tenure of representatives of major contributors to the network could be extended so long as they remained major contributors?

THE HEADQUARTERS LOCATION

8.4 INIBAP will only require a small central headquarters where its Director (? Global Coordinator) is located. Ideally, the headquarters would be attached to another research institution, so that logistic support could be supplied on a contractual basis. The INIBAP headquarters staff might be limited to the Director, his secretary and a finance officer (this latter function might also be carried out on a contractual part-time basis by a host institution official).

8.5 The location of the headquarters institution will be another task for the Steering Committee to decide upon. Several donors have suggested that it should be situated where the Director can spend part of his time in an active banana research program. This might be located at a national program site, at the location where a regional coordinator has his base or at a developed country institute with an ongoing banana research program. However, some concern was expressed by producing countries, in the regional consultations, that the location of the headquarters in any one region might bias the balance in the overall program and this would be undesirable since Africa, Asia and Latin America are roughly all of similar importance in terms of banana production. Indeed the Latin American consultation considered that there would be little time for the Director to do any personal research and his location should be determined entirely on grounds of logistics.

8.6 If the Director and the network are to have international status, it will, however, be important to locate the headquarters where such status will be made available. One solution to this would be to attach the headquarters to an international organization or research centre in either a developing or a developed country.

8.7 A memorandum of agreement and charter for INIBAP will need to be produced before the organization can be legally established. This should be a fairly straightforward task and could be done once the question of the headquarters location had been decided upon by the Steering Committee and agreed with the host government concerned.

THE DIRECTOR

8.8 The Director should be a senior scientist with considerable international and administrative experience, a knowledge of the CGIAR system and the donor community would be helpful. Ideally, he or she should also have specialized knowledge of bananas, particularly banana breeding - although this may be difficult to find. It is possible that the Director's role could be filled on a part-time basis initially, given the degree of autonomy envisaged for the regional networks, but as the program gathers momentum and particularly as germ plasm evaluation assumes a major role, it seems likely that his task will need to be a full-time one.

8.9 Provision has been made in the budget for some research funds to be made available to the Director, for work that he either conducts or directs, and it is envisaged that, if he is based in a developed country, the main thrust of this research would lie in the field of either tissue culture or plant pathology.

8.10 The main task of the Director will, however, be to prepare the work program and to coordinate the activities of the regional networks, in order to optimize the value of their results at the world level. In particular, he will be responsible for efforts to disseminate and evaluate promising germ plasm which has a potential role to play in raising yields and reducing losses; and for overseeing the documentation and information activities of INIBAP.

8.11 It will also be the responsibility of the Director to liaise with donors and to raise funds for INIBAP. He will have the task of organizing the meetings for the network's Board and its committees and for administering and reporting on the networks finances.

THE REGIONAL NETWORKS

8.12 The core of the global network would consist of initially three (Africa, Asia, and Latin America) and later four (East and West Africa) regional networks, each of which would have a large measure of autonomy modelled on the successful ongoing West African plantain network (WARCORP), whose mandate would be broadened to include bananas.

8.13 Each regional coordinator's task would be to:

a) Help national and regional programs to establish and implement research priorities;
b) Introduce, maintain and classify genetic material in order to facilitate its exchange;
c) Assist national programs and participate in the establishment and analysis of regional and global trials of new and improved cultivars;
d) Support national programs and participate in banana-based farming systems and socio-economic studies associated with the breeding program;
e) Promote the dissemination of documentation and information;

f) Provide training courses for the staff of national programs; and

g) Identify donors and assist countries in the development of proposals for donor support.

8.14 To assist him in his task, each regional network coordinator will need to be attached to an institution with research and training facilities. It is envisaged that the West Africa coordinator will be located at IITA, the East African coordinator at IRAZ in Burundi, the Asian Coordinator will probably be based at Los Baños in the Philippines and the Latin American countries have suggested that the most appropriate location for their coordinator would be at CATIE.

8.15 These locations will permit the coordinators to carry out their own research programs and to run training courses. They will also have funds for travel, for allocating individual research grants of up to $10,000 for research in member countries of their networks and for propagating and moving germ plasm. It is conceivable that the research and development activities of individual coordinators will be enhanced through direct bilateral grants to their offices as well as to national programs in their region.

8.16 In the WARCORP network national grants from network funds are allocated in consultation with a committee from the region. INIBAP will need to devise a mechanism that takes this kind of regional consultation into account whilst being acceptable to its Director and Program Committee.

THE PROGRAM

8.17 It is envisaged that the network will embrace not only a core program but will have direct linkages to both national programs (whether or not these be donor supported) and to developed country research. Hopefully, the network will, therefore, provide a forum at which these different activities can be related (Figure 2).

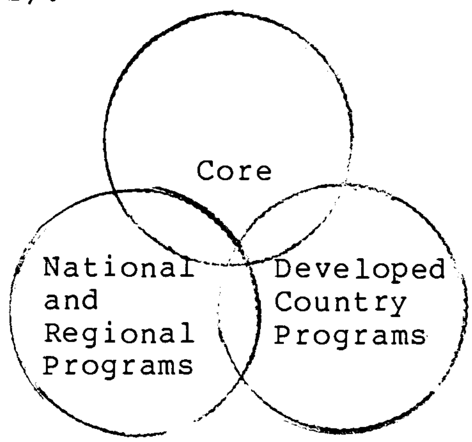

Figure 2 - Schematic Representation of Banana Network.

8.18 The core activities, as already noted, will be based upon regional networks which will assist in the strengthening of national programs through making available new germ plasm for testing, providing small grants for research, funds for technical workshops and occasional meetings and assistance for training, information and the development of projects for donor support. Similar activities are carried out by a number of CGIAR networks, the somewhat unique features of INIBAP are the provision of limited funds to national programs (the WARCORP model) and the support for donor-aided national programs. The latter could, and perhaps should, become the largest component of the network in financial terms. The advantage of linking donor-aided programs to the network should work in both directions.

8.19 On the one hand, it would give the overall network an awareness of bilateral and multilateral support for banana research and enable it to capitalize on the results of such research in its global mandate. On the other hand, it would permit the national programs and the supporting donors to draw on inputs from INIBAP which should, effectively, be the global focus for all matters appertaining to banana research. Obviously, the degree to which this link with donor-aided programs take place will depend very much on individual donors, but the prospects seem encouraging, given the interest shown in INIBAP by the key bilateral and multilateral programs currently providing some support for banana research and by the larger national programs, such as those in Brazil and Honduras.

8.20 Another feature of the proposed network would be its link to banana research being carried out in developed countries. This is intended to link the network to activities such as the ongoing tissue culture work in the U.S.A. and Belgium; the pathology work in Germany and Australia; the post harvest research in the U.K. and Australia and the work on a range of disciplines being conducted by IRFA in both France and overseas.

8.21 One task of INIBAP will be to try to bring all of the information on banana research together at an annual review, to which all interested parties would be invited. Such a review might be coordinated by a Program Committee of the INIBAP Board which might be made up of Board members, plus co-opted scientists who are specialists in bananas. This Program Committee might meet annually just prior to the INIBAP Board meeting,which would enable it to conduct an annual 'state of the art' review of current banana research, so that it could advise the Board where there were gaps which INIBAP might assist in filling:

a) By encouraging developed countries to undertake home-based research where this appeared appropriate.
b) By helping national programs to develop donor-assisted projects; or
c) Through the use of its own funds;

As a first step in the above direction, the research priorities listed in Appendix 4 offer some guidelines for future research orientation.

8.22 Another goal of the network would be to try to strengthen information and documentation services. There are currently various sources of information regarding banana research. One of the strongest is the service offered by IRFA with its quarterly bulletin 'Fruits'. An information service is also run by the Latin American Banana Exporters Union (UPEB) assisted by IDRC. Abstract services covering bananas include the Commonwealth Agricultural Bureau (CAB), FAO (AGRIS), WINBAN and the Royal Tropical Institute in Amsterdam. WARCORP publish a bulletin called 'PARADISIACA' which deals mainly with plantains.

8.23 As yet there is no global Documentation Centre but a series of partial services operating in three different languages. IRFA and IDRC have expressed an interest in bringing together these various services to see whether a global documentation service could be structured and established. Given the number of institutes involved and the language question, it is feasible that the optimum solution would be some form of hierarchial network. Further discussions on this are dependent upon the decisions made at the meeting to which this paper is addressed. At this point in time, it is not possible to forecast what sort of documentation service will finally emerge, and how it would link to INIBAP - although it is important that the two activites should be integrally related.

8.24 Reference has already been made in parts 5 and 7 of this paper to the training role of INIBAP, and for the need to focus both on production training and on special short courses in specialized subjects. The locations at which the coordinators will be posted will be selected with the training role in mind. However, very limited provision has been made for training in the budget presented below, as it is presumed that extra-core funds for training will not be unduly difficult to obtain from bilateral and multilateral sources.

THE CORE BUDGET

8.25 The start-up date proposed for INIBAP is January 1985, with a 1985 budget of just under one million dollars for what would be a global and three regional networks. The core budget would rise to 1.75 million dollars by 1988 when four networks would be expected to be fully operational.

8.26 The table below summarizes the budget for the first four years. The figures are indicative and are included to provide an idea of the possible costs. It is suggested that the network be reviewed in depth at the end of year three, as it represents a somewhat innovative approach, and that a quinquennial work plan and budget then be prepared for years five to nine.

8.27 In the budget below 33% of the expenditure is devoted to the coordinators and 36% to research (25% in national programs and 11% by the coordinators). Assuming that the program is successfully associated with bilateral activities, as discussed earlier, the coordination costs of the total program should drop to a low percentage and the research cost element rise accordingly over time.

	US $'000				
	Y1	Y2	Y3	Y4	Total
Scientists	350	525	550	600	2,025
Secretaries	35	52	55	60	202
Travel	70	100	110	120	400
Field work	120	180	180	200	680
Workshops	30	120	120	140	410
Subtotal	605	977	1,015	1,120	3,717
18% overhead to host institution	109	176	183	202	670
Board costs	30	30	30	30	120
Subtotal	744	1,183	1,228	1,352	4,507
National programs	250	400	400	400	1,450
	994	1,583	1,628	1,752	5,957

CORE BUDGET ASSUMPTIONS

8.28 Scientists — 3.5 in Y1, 5.0 in Y2, Y3 and Y4 with East African network included in last three years. Base cost $100,000 per m.y. in Y1

Secretaries — Base cost $10,000 per unit in Y1

Travel — Base cost $20,000 per scientist

Field work — Base cost $40,000 per annum per regional coordinator $20,000 for global coordinator

Workshops — Base cost $30,000 each. One in Y1, four in Y2, Y3 and Y4

National Programs — Approximately $80,000 per coordinator. These funds are intended to be flexible according to regional priorities and could be used for small projects within national programs (as at WARCORP) for exchange visits or for germ plasm propagation and exchange activities.

8.29 Discussions with individual donors suggest that the format of the INIBAP budget contributions will need to be very flexible. Some donors have expressed the possibility of support by means of providing a scientist, others have indicated that they wish their contributions to be restricted to a specific region. The outline proposed in this paper should accommodate both of these options providing that at least some donors are prepared to be very flexible with regard to the use of their contribution.

THE STEERING COMMITTEE

8.30 The Steering Committee proposed earlier in this paper would need to come into existence and to hold its first meeting during the period of the May 1984 CGIAR meeting in Rome. Its tasks would be to:

1. Identify the structure and membership of the Board of Governors.
2. Select the headquarter's location.
3. Either select the Director or prepare a short list for the Board to choose from.
4. Approve the network's charter.
5. Propose a budget for 1985-1988.

The Committee's goal should be to complete these tasks, if possible, by the end of October 1984, with a view to appointing a Board and holding a pledging session at Centres Week in Washington in November 1984. This would permit the network to become operational early in 1985. In order to do this, the Committee will probably need to establish some form of secretariate to assist it in the tasks listed above.

APPENDICES

1. An International Banana and Plantain Breeding Program (background paper for a meeting in Washington on November 1, 1983).

2. Minutes of a preliminary meeting on an International Banana Improvement Program held in Washington on November 1, 1983.

3. Estimated World Production of Bananas and Plantains in 1981.

4. Report of a meeting of specialists to discuss Banana Research Priorities, held at Gatwick on December 20, 1983.

5. Classification and Breeding of the Bananas. Paper presented by N.W. Simmonds at a Workshop on Banana Production and Research in Central and Eastern Africa held in Burundi December 14-17, 1983.

6. Current inputs to Banana and Plantain Research - some preliminary data.

7. Recent Regional Consultations on Banana Research and the Role of an International Network. A note based upon draft reports from meetings or consultations in East and West Africa, Latin America and the Caribbean, South East Asia and the South Pacific.

8. Recent documentation relevant to a Banana Research Network.

BACKGROUND PAPER FOR
AN INTERNATIONAL BANANA AND PLANTAIN BREEDING PROGRAM
WASHINGTON - NOVEMBER 1, 1983

Bananas and plantains are important food crops in many tropical countries and nearly 90 % of the total production of these two crops is consumed domestically in Third World countries with the residue being exported to developed countries. In recent years, both crops have suffered serious losses from a form of leaf-spot named Black Sigatoka. Most cultivars appear to be susceptible to this disease which first appeared in Central America in 1972 and in West Africa less than a decade later. A few resistant cultivars have now been found, although these have different organoleptic characteristics to the varieties commonly eaten in many countries.

A number of international meetings have stressed the urgency for action to combat the worst effects of Black Sigatoka by:

(a) multiplying varieties thought to be resistant,

(b) undertaking wider screening for resistance in known varieties, and

(c) breeding for resistance.

Unfortunately, however, there are major constraints to the implementation of these recommendations in that:

(a) there are only two major on-going banana breeding programs, both of which are faced with uncertain futures, and,

(b) whilst tissue culture techniques, which would permit both rapid multiplication and the international transfer of disease-free clonal material have made considerable progress they are, as yet, imperfect.

Although tissue culture research can be and is being carried out in laboratories away from banana producing areas, the breeding work itself has to be done in producing areas. Of the two main breeding programs in existence, that of the Jamaica Banana Company has been under way for more than 30 years but is now severely constrained by a shortage of funds.

The program of the United Fruit Company in Honduras dates back more than 20 years but is now facing possible closure (for commercial reasons). Both the Jamaican and the Honduran programs are strongly biased towards the production of export bananas although both contain germplasm, particularly diploids, that possesses considerable potential for producing improved cooking bananas and plantains. Because of their commercial orientation, the available diploid materials have only been used to a modest extent to produce improved plantain varieties for local consumption and have not been made generally available to other countries.

The need to broaden the scope for banana/plantain breeding and for some form of an international program and network for this crop is well documented in the report of a workshop of banana experts held in Ottawa in July 1982. The need is further supported in the recommendations from two meetings of the IBPGR Working Group on the Genetic Resources of Banana and Plantains (1977-1982) and from two meetings of an UNCTAD Inter-Governmental Group of Experts on Bananas (1980-1982). Both sets of meetings identified the need for more research on bananas and plantains with the development of new varieties as a top priority. The Latin American and Caribbean Association of Banana Research Workers (ACORBAT) and the West African Regional Cooperative for research on plantains (WARCORP), the export producers organization in Latin America (Union de Paises Exportadores de Banano - UPEB) and the International Association for Research on Plantain and other Cooking Bananas (IARPCB) have all reported on the critical state of banana and plantain breeding and the need for action to control the spread of Black Sigatoka.

However, limited progress has been made towards any coordinated international activity, although increasing attention has been given to banana germ plasm improvement in several countries. This includes a major effort by EMBRAPA in Brazil to establish a national banana breeding program, the establishment of a regional south east Asian banana collection in the Philippines with support from the IBPGR, who have also supported germ plasm collections in Indonesia and Thailand and the maintenance of a germ plasm collection in Papua New Guinea. Breeding work has started recently at IFRA in Guadeloupe and, with IDRC support, small agronomy and selection programs are in progress on bananas in the Philippines, and plantains in Cameroon. (This list is not exhaustive, but merely indicative of some recent activites.)

Progress in breeding for Sigatoka resistance and for improved plantains and cooking bananas is, however, likely to be very slow unless the diploid material in the Jamaica and Honduras programs can be utilized, both in these programs and in national breeding programs.

Jamaica has expressed its interest in internationalizing its national program. A paper prepared by the Banana Company and dated October 8, 1981 states:

> "The Government of Jamaica is anxious to re-activate the Banana Breeding Research Scheme, now virtually dormant, on the grounds outlined that such an operation is essential to the future of banana growing. However, an effective programme cannot be maintained, nor should it be expected, within the resources of the existing contributors. Jamaica is therefore proposing that the scheme be either financed by International Funding Agencies, be acceded as part of an International Agriculture Research Organization or contributed to by Governments interested in bananas."

More recently, the report of the UNCTAD intergovernmental group of experts on bananas in November, 1982 contains a statement by the Jamaican delegate that her government offered facilities in her country for:

> "an international centre for banana breeding with formal coordinating links with other research institutions, envisaged as part of an international network for banana breeding and germ plasm collection".

Recent discussions with the Jamaican Government and with officials of the Banana Company indicated little change from the views expressed above. The Jamaican Government would, however, require some reassurances about the duration and extent of international support before being prepared to make freely available the synthetic diploid male parent material which has resulted from 30 years of selective breeding. There appears to be no problem with regard to distributing the progeny of this material including new tetraploid sweet bananas (which are claimed to be showing resistance to black sigatoka in preliminary tests in the South Pacific). Further discussions on the distribution of diploids are underway and the Jamaican Government is preparing a note on its views on this topic.

In Honduras the United Fruit Company have announced that they are reducing their budget for banana breeding, so that the future of the collection is somewhat uncertain (see attachment). There is now reported to be some UNCTAD/FAO funding for this program, including some staff members. The implications of this with respect to the availability of this formerly private sector collection are not yet clear. Were the collection to be made more widely available it could undoubtedly play an important role in any international program. Should both the Honduran and the Jamaican collections become available internationally, the prospects for progress in banana and plantain improvement would be enhanced.

Given the interest in banana and plantain improvement by several national and international organizations, a meeting of potentially interested donors to discuss the relevant issues would appear timely.

To this end, it is proposed that a meeting be held at the World Bank in Washington, preferably after the C.G. meeting ends on the afternoon of Tuesday, November 1. Your reaction to this proposal in terms of participation and timing will be most welcome.

INTERNATIONAL BANANA IMPROVEMENT PROGRAM - PRELIMINARY MEETING
WORLD BANK - WASHINGTON, NOVEMBER 1, 1983

MINUTES

1. Chairman's Introduction

The meeting was opened by Dr. J.H. Hulse of IDRC, who explained that IDRC had been invited by a number of donors to call an exploratory meeting on the subject of plantain and banana improvement.

2. Presentation by Dr. B.L. Nestel - IDRC Consultant

Dr. Nestel pointed out that plantains and bananas are important food crops in many tropical countries, and nearly 90 percent of the total production of these two crops is consumed domestically in the producing countries, with the residue being exported to developed countries. He emphasized the constant threat of devastating disease epidemics which may attack these clonally propagated crops which, in most countries, have a very narrow germ plasm base. In particular he stressed the damage being done by the black sigatoka variant of the leaf spot disease which was spreading through Central America and West Africa.

A number of recent international meetings of banana specialists had stressed the urgent need for action to combat the worst effects of black sigatoka by:

a) multiplying varieties thought to be resistant;
b) undertaking wider screening of resistance in known varieties; and
c) breeding for resistance.

The representatives of national plantain/banana research programs present at these meetings had particularly stressed the need for some form of international support for their programs, both by providing additional germ plasm and information exchange facilities, and possibly by assisting them in obtaining additional resources for their programs.

In particular, the two oldest established breeding programs, in Jamaica and Honduras, were both experiencing considerable difficulties in continuing their breeding activities, although these two programs offered the best opportunity for developing disease resistant material of both plantains and bananas.

IDRC therefore was seeking the views of those present as to the desirability of establishing some form of international plantain/banana improvement program which could: assist in strengthening linkages between national programs; facilitate the international transfer of both germ plasm and information; and possibly, assist in establishing one or more international breeding programs.

3. The Honduras Banana Research Program

Dr. Rowe, the banana breeder in the United Fruit Company's Honduras program explained that the company had decided to cease supporting banana breeding research at the end of 1983. The program in Honduras had recently identified resistance to both black sigatoka and nematode. These resistances could probably be incorporated in useful cultivars within five years.

Dr. Contreras, representing the Government of Honduras, explained that the banana breeding program would be handed over to the Government, which wished it to have both a national and international role.

4. The Jamaica Banana Breeding Scheme

Dr. Franklin, the Managing Director of the Jamaica Banana Company, gave a brief account of the history of the banana breeding scheme, and described the extensive collection of both parent material and tetraploids which had been developed in the scheme.

He added "the Government of Jamaica is therefore actively seeking international support for the scheme and is willing to receive this support within the framework of an informal international network with the participation of representatives of funding agencies and donor governments in the formulation and implementation of policies governing the banana breeding research scheme activities and the network as a whole".

5. Conclusions

After a lengthy discussion a clear consensus emerged that the timing was appropriate and sufficient support would be forthcoming for some form of international initiative on plantain/banana improvement.

There appeared to be agreement that a large international centre for banana research analogous to the CGIAR centres would not be appropriate. A clear preference was expressed for some form of informal collaborative research program which would link interested donor agencies with a series of bilaterally or multilaterally funded projects associated together in some form of network.

IDRC was asked to consult further with national banana research programs, banana specialists and possible donor countries and agencies, and to present a more formal proposal to the next meeting of the donor group to be held on May 22, 1984, before the CGIAR meeting at Rome.

Att.
Jan.10/83

INTERNATIONAL BANANA IMPROVEMENT PROGRAM - PRELIMINARY MEETING
World Bank, Washington
November 1, 1983

ATTENDANCE LIST

Africa	Dr. J. Kasembe
ACIAR, Australia	Dr. J.R. McWilliam Dr. G. Persley
Belgium	Mr. E. Martens
Cameroon	Dr. J.P. Eckebil
CGIAR	Dr. D. Plucknett Mr. P. Greening Dr. R.W. Herdt
CIDA, Canada	Mr. E.N. Hare Dr. G. Ouellette Mr. G. Spendjian
CIMMYT	Dr. V. Barco
FAO	Dr. J. Monyo
France	Dr. G. Vallaeys Mr. H. Tezenas du Montcel
Germany	Dr. U. von Poschinger-Camphausen
Honduras	Dr. M. Contreras Dr. P. Rowe
IBPGR	Dr. N. Murthi Anishetty Dr. J.T. Williams
IDRC	Dr. J.H. Hulse Dr. B.L. Nestel Mr. A.D.R. Ker
IFAD	Dr. A. Kesseba
IITA	Dr. C.H.H. ter Kuile
India	Dr. M.V. Rao
Jamaica	Mr. C. A. Franklin Mr. I. M. Muirhead

Netherlands	Dr. J.J. Hardon
Norway	Dr. O.M. Heide
Rockefeller Foundation	Dr. J.E. Johnston Dr. J.M. Lyman
SAREC	Dr. B. Bengtsson
Sweden	Dr. N. Nykuis
TAC	Dr. W.V. Urff Dr. L.H. J. Ochtman Dr. P. Roberts-Pichette
United Kingdom	Dr. J.C. Davies
U.S.A.	Dr. A.L. Brown Dr. P. Lippold Dr. H. Davis
World Bank	Dr. J.R. Coulter Dr. E. Sicely

ESTIMATED WORLD PRODUCTION OF BANANAS AND PLANTAINS (1981)

Million Tonnes	Africa	Latin America	Asia	Europe/Oceania
5+		Brazil 6.7*		
4-5			India 4.5 Philippines 4.3*	
3-4	Uganda 3.9*	Colombia 3.6* Ecuador 3.0*		
2-3	Nigeria 2.3* Rwanda 2.1*		Thailand 2.0*	
1.8-2.0	Zaire 1.8*		Sri Lanka 1.8	
1.6-1.8	Tanzania 1.6*	Mexico 1.6	Indonesia 1.6*	
1.4-1.6		Honduras 1.5* Venezuela 1.5*		
1.2-1.4				
1.0-1.2	Cameroon 1.1*	Panama 1.2* Costa Rica 1.2*		
0.9-1.0	Ivory Coast 1.0* Burundi 1.0*			
0.8-0.9	Ghana 0.9*	Rep. Dom. 0.9	Vietnam 0.9	PNG 0.9*
0.7-0.8		Peru 0.8		
0.6-0.7		Guatemala 0.6	Bangladesh 0.6	
0.5-0.6		Haiti 0.5	Malaysia 0.5*	
0.4-0.5	Kenya 0.4*	Bolivia 0.4	Burma 0.4	Spain 0.4
0.3-0.4	Guinea 0.3 Angola 0.3 Madagascar 0.3	Paraguay 0.3	China 0.3	
0.2-0.3		Argentina 0.2 Nicaragua 0.2 Cuba 0.2 Puerto Rico 0.2		
0.1-0.2	Egypt 0.1 Liberia 0.1 S. Africa 0.1	Guadeloupe 0.1* Jamaica 0.1*	Pakistan 0.1	Australia 0.1*

*Denotes countries that have either been represented at 1983/84 workshops associated with this network study on have been consulted specifically on this topic.

REPORT OF AN INFORMAL MEETING ON BANANA RESEARCH

held at

the Gatwick Airport Hilton Hotel

on

Tuesday 20 December, 1983

1. INTRODUCTION

This meeting was organised by IDRC as one of a series of follow-ups to a meeting of a number of CGIAR donors in Washington on 1 November 1983. The Washington meeting was convened to discuss the possibility of creating an International Research Network for Bananas and Plantains. At the end of the meeting, the donor group asked IDRC to co-ordinate discussions on the topic and to prepare proposals for action, to be discussed by interested donors in Rome in May, 1984. IDRC was asked, in the preparation of these proposals, to consult, not only with donor countries and with those producing bananas and plantains, but also with scientists who had specialised knowledge of the crop.

The meeting to which this report refers falls into the last category. It was attended by Drs J Champion and J Ganry (France), E A L de Langhe (Belgium), and N W Simmonds (UK), with Dr B Nestel (IDRC) acting as convener and rapporteur. Dr Simmonds chaired the meeting, which addressed itself to seven specific groups of questions on international banana and plantain research. The questions and a summary of the views expressed on them by the group are as follows.

2. REPORT

1. *What is the current state of knowledge of food banana production? Is there adequate information from the main producing areas regarding: what clones exist; their agri-social role; and their diseases and pests? What steps need to be taken by the proposed network to broaden this information base?*

The group thought that a good general knowledge of existing clones is fundamental and that, in most banana producing countries, such knowledge does not exist. The description of clonal material is confused by the complexities of nomenclature, the same clone often being known by several different names within one country. The situation would be eased by the wider use of the descriptor list currently being produced by the IBPGR. This list, though designed for a slightly different purpose, could readily be adapted to local identification and listing.

There is, perhaps, more knowledge of the role of bananas and plantains in agricultural systems than there is about the banana germ-plasm available. However, this understanding tends to be very location-specific. Where bananas are grown in monoculture for export markets, knowledge of husbandry is excellent but this is seldom true when the crop is grown in backyard systems or as a major component of more extensive food-cropping complexes.

It is difficult to differentiate between the role of bananas in an agricultural system and their role in a particular culture. The local importance of the crop relates closely to the degree to which that society is dependent upon it. In some cultures, the banana is an optional dietary component but, in others, it is a major source of dietary calories. In societies highly dependent upon the banana, there usually appear to be quality preferences; current knowledge both about the rationale of these practices and the physiological factors which determine quality is sparse.

There are many pests and diseases that affect the crop; some of them are already serious and some others have the potential to become so. The disease picture in general appears to be changing, with some diseases that were unimportant several years ago now becoming very significant. This highlights the danger of over-dependence on limited numbers of clones and stresses the need for developing a broad range of widely adapted genetic material.

In spite of all the many deficiencies of knowledge of clones and production systems, the group thought that this was not a topic which would benefit from a broad-ranging state-of-the-art review. Such reviews might be useful globally for certain disciplinary level problems, but the type of information being discussed here was so location-specific that it was best acquired by country programmes feeding in appropriate information to regional networks, rather along the lines of the recent Eastern and Central African meeting in Burundi.

2. *Given the existing knowledge of the crop, what priorities are recommended for research on: (a) collection; (b) uniform regional trials; (c) crop husbandry; (d) crop physiology; (e) pathology; (f) fruit physiology; (g) socio-economics?*

The group thought that international collection work was already in the hands of the IBPGR and best left there. At the local level, within countries, the establishment of working collections is a basic priority; there is also a general need for regional working collections containing, selectively, the best germ-plasm from the local/national collections, but with some representation also from the international collections. Regional collections exist at Davao in the Philippines and at Ekona in West Africa, and they will no doubt prove to be valuable sources of material in the future. Other collections need to be established in East Africa and the Americas. In this context, Asia and Africa justify a higher priority than the Western Hemisphere, since banana germ-plasm is much more diverse in Africa and Asia than it is in the Americas.

Because most bananas and plantains are grown on small farms, the group thought that the IARC model of uniform regional trials was both impractical and unrealistic. Evaluation work on bananas should be conducted on the basis of on-farm trials under mixed cropping, with the evaluation of the variety under test being based on its local utility in the small farm context.

Similar considerations apply to research on crop husbandry. The husbandry features of the commercial crop are well enough understood but small-farmer problems and methods are highly location-specific. There does not appear to be a case for international research in this area. A case can, however, be made for conducting work on crop physiology at a central research station, since such work could be globally relevant. A similar consideration applies to fruit physiology where there is an urgent need to develop clear criteria for characterising varieties by their quality features, specifically their starch, sugar and acid contents during ripening. Such work would be relevant to the understanding of the utilisation, storage and post-harvest management of different cultivars.

A great deal is known about the pests and diseases of bananas and there is a standard work on banana diseases. Many pests and diseases can be (more or less) controlled by chemicals but their use on small farms is generally irrelevant. In the main, genetic resistance to pests and diseases will be necessary, supplemented by good husbandry. The main role of pathology research lies in disease-indexing to facilitate safe transmission of clonal materials but there will also be some need, *ad hoc*, for research on new disease/insect problems if and when they arise.

With regard to socio-economic research, the group thought that this came into the same category as crop husbandry and uniform regional trial activities; it belonged with on-farm research and should be a component of national programmes, rather than of any central core activity.

3. *What is the recommended international strategy for a breeding programme?*

The group thought that the core of an international breeding programme would need to be located in the American tropics because of the absence there of bunchy top disease and because of the presence there of long-established breeding sites (in Jamaica and Honduras). But for the programmes in these latter two locations to play an important role internationally it would be essential for them to permit their breeding material at any stage of development to be freely available to any country participating in the programme. There could be no qualification of the principle of freedom of genetic exchanges.

The key objective of the programme should be to breed bananas as a food crop, which implies that the products must be genetically diverse. Some crosses appropriate to this objective might produce clones worth consideration for the export trade but this objective should be strictly subsidiary. The breeding programme should use, not only established techniques, but should maintain an open mind about the use of new methods and should have associated with it a strong meristem culture activity to facilitate the international distribution of banana germ-plasm.

It was recognised that several national programmes had already started or might undertake breeding activities in the future; such action would be complementary to that undertaken in those countries with long standing breeding programmes having a broad genetic base. Newer programmes could not substitute quickly for those that were well established but could benefit considerably from being closely linked with them.

Taking into account the views expressed in Section 2 of this report, the group thought that any international effort to strengthen breeding activities in Jamaica or Honduras should involve only a small team(s) of personnel, probably four to six senior scientists who would focus strongly on breeding activities.

4. *Can research priorities be specifically related to recommended regional activities in Africa, Asia, America and developed countries?*

The group thought that the prime need was for three strong regional networks and that there would be opportunities in each of them, when work was required in depth, to attack specific disciplinary problems. The regional network programmes should be built from the bottom up, according to the problems and the resources available in each region. The group saw the regional networks as having three major needs or components. The first is a producer-country scientific group, such as WARCORP or ACORBAT. The second is a lead-institute that would probably maintain the regional germplasm collection and carry out such other regional functions as training. (At present, the only clearly identified institute in this category is IITA.) The third need of the regional network is a source of funds, such as IFAD has provided in Africa and ACIAR is considering for South-East Asia.

There are several research activities which could be carried out cost-effectively through collaboration with laboratories in developed countries, particularly in fields such as fruit and crop physiology and meristem culture. The need for such research would be identified in the first instance by a regional network and channelled towards laboratories having the appropriate expertise.

5. *Is there an adequate documentation centre for the crop? If not, what are the needs for an information service?*

There appear to be two current services which provide specific documentation on bananas and plantains. One is the long-standing abstract service of IRFA and the other is a rather newer programme at UPEB, supported by IDRC. The group was not able to identify any clear linkage between the two programmes and it is possible that some duplication exists. In view of the amount of material being generated by both programmes and the importance of a good information service to researchers, it was felt that there was need for a dialogue between IDRC and IRFA on the subject. The matter was brought to the attention of IRFA at the meeting and Dr Nestel agreed to relay the group's concern to IDRC in the hope that it (IDRC) would consult with IRFA on the subject.

6. *Given the limited facilities available for training banana specialists, are there any measures that ought to be taken by the proposed network to increase specialised competence in the crop?*

It was thought that there was an important need for IARC-type production training at a fairly basic level, that this should be regionally based and that it should be an important component of the developing regional networks. To make such a suggestion workable, each of the regional networks would need to have a central, focal point where such training coul be carried out. At present, this is only possible in Africa, through the activities of IITA. The group thought that the provision of basic banana production training would be the best way to help to develop national capabilities to cope with the problems of clonal exploitation and agri-social systems identified above as being of high priority.

This production training should be brought into the regional networks very early. Later, there would be a need for more specialised, higher level, training to provide scientists in national programmes with expertise in particular topics, such as shoot-tip culture. This, too, would require a central training facility, such might be found in an IARC or a large national programme.

7. *Is there a role for the network to play in holding global 'state-of-the-art' workshops on problem topics?*

The group thought that this could become an important role but that, in the earlier years, the networks should focus on regional activities in order to help establish research programmes in constituent national centres. The first priority should be to secure the basic background information on banana germ-plasm, cropping systems and socio-economic implications; thereafter, more specialised international seminars on an *ad hoc* basis, according to need, would no doubt be appropriate. However, there could conceivably be exceptions to this rule; one that the group foresaw was that of quarantine, where in a massive educational effort would be needed to convince quarantine authorities of the reliability and safety of meristem culture, without which germ-plasm exchange would be difficult, perhaps even virtually impossible.

8. *What should be the structure of an international network?*

The group thought that, although the networks should have a strong regional emphasis, there would be considerable merit in having an overall guiding body (a Board of Directors, maybe) on which both producing countries and donors should be represented. Possibly, representation could be on a regional basis. With this type of governance, there would probably also be a need for some form of scientific advisory committee, which might review the programmes and report on them to the main Board. The need for some such structure is especially apparent in relation to the proposed banana breeding operation which must, of its nature, lack a regional focus.

The group thought that, in the interests of orderly administration, it would be desirable that all the money should be controlled by the Board. It recognised, however, that several donors had expressed a preference for a network-type structure, with bilaterally funded projects. This would imply that the Board should be a co-ordinating (rather than a directing) body. As a possible compromise, donors might agree to contribute an overhead on their network activities to the Board for its use in areas of work otherwise insufficiently supported by bilateral funding. To service the Board and provide day-to-day co-ordination/ guidance to the regional networks, there would probably be a role for a very small central secretariat. Given that donors ultimately prefer the network-type structure referred to above, the chief executive is more likely to be an 'executive secretary' or 'secretary-general' than a 'director-general' (in international research parlance).

In conclusion, the group recognised that donors themselves would have to decide how to spend their money; but it hoped that the central body would be strong enough to help to shape a coherent global programme and guide both the regional networks and the breeding programme jointly along fruitful lines.

3. SUMMARY

1. This is a report of a meeting held in December 1983, at the request of potential donors, to consider the broad shape of research on bananas *as a food crop*. Those present were: Drs Champion, Ganry, de Langhe, Nestel and Simmonds.

2. The group identified, as leading priorities:

   i. the identification and evaluation of banana clones in producing countries;

   ii. the socio-agricultural understanding of banana production and utilisation systems;

   iii. the development of an international banana breeding scheme aimed primarily at the food crop.

3. As an approach to the above objectives, the group thought that collections (national and regional) and on-farm research would play important roles and that husbandry, physiological and pathological studies would be secondary, even if locally useful.

4. On breeding, the group though that a strong central breeding scheme, with global responsibility, probably centred on Jamaica and/or Honduras, was fundamental to success. The shoot-tip/meristem culture technique, already established, is essential to disseminate both the products of breeding and the many good clones already available but not yet universally spread.

5. As to working structure, the group foresaw the need for the following:

   i. Three regional networks in, respectively, Asia, Africa and America (one is already developing well in Africa);

   ii. the international breeding programme referred to above.

6. Each of the three networks would need to have a 'lead-institute' and adequate funds to carry out its functions of co-ordination, training

and some research support. Global, 'state-of-the-art' workshops might be an appropriate function later, but probably not at first.

7. Administratively, the group foresaw some sort of a small secretariat and governing body, with a scientific advisory committee. It recognised that various structures were possible and understood that donors were inclined to favour a loose network under bilateral funding. But it, the group, hoped that the central body would be strong enough to help to shape a coherent global programme and guide both the regional networks and the breeding programme jointly along fruitful lines.

IRAZ/IDRC BANANA WORKSHOP, BURUNDI

Classification and Breeding of the Bananas

N W Simmonds

Edinburgh School of Agriculture

November 1983

1. INTRODUCTION

The bananas are of great socio-economic importance in the moister areas of tropical agriculture. They are soil-conservative, productive, almost non-seasonal and they yield diverse foods from sweet fruits to staple starches as well as numerous useful secondary products, from fibres to wrappings.

For all their importance, they have been sadly neglected in their food-crop role by tropical agricultural research systems. It is fitting that this meeting should be held in one of the great areas of banana cultivation and I hope that it may signalise the beginning of improved understanding and exploitation of this marvellously useful and attractive group of plants.

2. EVOLUTION

a. General

1. The genus *Musa* contains about 30-40 species, all diploids (2n = 2x = 14, 18, 20, 22) and all native to South-East Asia, from India and Thailand to New Guinea and Queensland. Only two species are of importance for our purpose (*M. acuminata* and *M. balbisiana*) but the genus also contains Manila hemp (abaca, *Musa textilis*). The related genus *Ensete* is of great local economic importance in Ethiopia, where it is the foundation of a unique agriculture.

2. *Musa acuminata* (AA) and *Musa balbisiana* (BB) are both diploids with 2n = 22. The first (and crucial) step in the evolution of the edible bananas was the development, under human selection, of parthenocarpy and seed-sterility in *M. acuminata*. This gave rise, in South-East Asia, to the edible diploid cultivars (AA), which survive in some numbers to this day though economically of little importance. Parthenocarpy is the capacity of the fruits to grow and become full of edible parenchymatous pulp without pollination. Seed sterility is due to cytogenetic factors and is also very important because banana seeds are stony and most unpleasant to encounter unawares. Edibility, therefore, is parthenocarpy plus seed sterility.

3. From the AA cultivars, by chromosome restitution at meiosis, there arose the AAA (*acuminata*) triploids, one of the three most important groups. They include both the important export cultivars but many others, too.

4. Another important step, also taken in South-East Asia, was the crossing of AA (and perhaps AAA) cultivars with wild *Musa balbisiana* (BB) to form the interspecific hybrid groups of cultivars listed in Figure 1. *Musa*

Figure 1

balbisiana is a hardier and more drought-tolerant plant than *M. acuminata*, so the hybrid groups not only extended the range of plant characters and quality features but also helped to extend the geographical range of the bananas, out of the wetter tropics into the seasonally drier zone.

5. In South-East Asia, the bananas are probably several thousand years old; we have no good dates. About 2000 years ago, they spread in the hands of travellers, eastwards to the remoter Pacific Islands and westwards to Africa (probably via Madagascar). The first European visitors to West Africa found them there and several clones were taken to the New World

very soon after discovery. There, the crop spread very rapidly. The present distribution (Figure 2) is roughly 30^0 north and south and bananas are grown wherever there is frost-freedom and enough rain.

Figure 2

b. Classification

1. It has been found that systematic scoring of characters diagnostic of the two parental species and chromosome counting jointly suffice to diagnose the main cultivated groups. They are designated by genome constitution, thus: AA, AAA, AB, AAB, ABBB (Simmonds & Shepherd, 1955; Simmonds, 1966; IBPGR, 1983). The other groups mentioned in Figure 1 (AAAB, AABB — Richardson *et al.*, 1965) have not yet been fully classified but should present no great difficulty. A descriptor list has been published (IBPGR, 1983).

2. Ploidy, of course, is normally established by chromosome counting but the experienced observer can usually diagnose it by eye. It does take experience to do so, however. Diploids are slimmer and have more erect leaves than polyploids.

3. Within each group there are clones which can formally be referred to thus when required:

Musa AA Group cv. 'Sucrier'
Musa ABB Group cv. 'Bluggoe'

There are also many somatic mutants that affect many characters. Sometimes they receive distinct names (as 'Highgate' is a dwarf mutant of 'Gros Michel' and 'Rajapuri' a dwarf mutant of 'Nendra Padaththi'). Occasionally, there are very many mutants, when it may be convenient to refer, for example, to AAB Plantain Subgroup (informally, the Plantain group).

c. Characteristics

1. It is generally believed that triploids preponderate among the cultivated bananas because they have been selected for superiority over diploids in terms of vegetative vigour and yield. This is probably true but has never been formally tested. Tetraploids are about as vigorous and productive as triploids and this has been tested for AAA vs AAAA. Tetraploids must be an important feature of any banana breeding programme (Figure 4).

2. I said above that *balbisiana* genomes were important for diverse quality characters as well as for conferring hardiness and disease resistance. Broadly, B genomes give starchiness and acidity to the fruit (Figure 3), characters which are features of cooking quality to many

Figure 3

consumers. But it should be noted that starchiness depends greatly on ripeness, so potentially sweet (AAA) bananas are starchy and non-sweet if cooked green (as many people do, in fact, cook them). Again, we are rather ignorant: Figure 3 is probably correct in outline but good comparative chemical data are lacking. As to hardiness and disease resistance, *Musa balbisiana* itself always looks better in drought than any cultivar and it is, in effect, disease-free: I cannot recall even having seen it infected by Panama disease, leaf spot or nematodes. Cultivars containing B genomes are not so hardy or so resistant as the wild species itself but they are, on balance, I think, better in both respects than AA or AAA clones and the ABB Group is certainly pretty tough.

d. Agricultural importance

1. The *acuminata* Groups, AA, AAA and AAAA, are of very unequal importance. Only one AA clone ('Sucrier') is widespread but others persist in their original haunts in South-East Asia, from Malaysia to New Guinea. Their principal value lies in breeding potential as male parent breeding stocks (see below). The AAA Group is widespread and very important indeed. It provides the two leading export cultivars (and their mutants): 'Gros Michel' and the 'Cavendish Subgroup'; also the leading clones used in the great food-crop cultivations of upland East Africa, around Lake Victoria. The latter, though AAA clones, are *treated* as cooking bananas by the growers/consumers. A number of good AAAA clones exist but are yet unexploited.

2. Of the hybrid Groups, AB, AAAB, AABB and ABBB are all scarce and unimportant (so far — food-crop breeding might well change that). The AAB and ABB Groups, by contrast, are very important indeed. Several AAB clones such as 'Mysore' and 'Silk' are widespread and highly valued as producers of fresh fruit, 'Mysore' being particularly vigorous and productive and the leading variety in India. Another important element in AAB is the Plantain Subgroup, the most complex assemblage of mutants in the bananas. The Plantains are especially abundant in West Africa (and are characterised there by remarkable diversity of mutants) and also in parts of tropical America. They are virtually absent from upland East Africa and uncommon in South-East Asia. One notes that, though of the same taxonomic Group as 'Mysore' and 'Silk', the Plantains are distinctively cooking bananas (Figure 3), so the AAB Group is diverse in a culinary sense.

The ABB clones are fairly numerous, especially in India and South-East Asia and being two-thirds *balbisiana* are essentially all cooking bananas (Figure 3). 'Bluggoe' and 'Sabah' are widespread, locally very important and tough, hardy plants.

3. BREEDING

a. Commercial breeding

1. Breeding has been carried on for many years in the West Indies (Trinidad and Jamaica) and in Honduras (United Fruit Company). The object was to breed new export bananas. Both programmes produced clones that, it is believed, could have been exported but, in fact, were not. Both programmes have now been run down, so that there is no longer any active banana breeding in progress but there remains the cytogenetic knowledge, the 'knowhow' about banana breeding, to serve as a basis for food-crop breeding. General references are; Simmonds (1966); Shepherd (1968); Menendez & Shepherd (1975); Rowe & Richardson, 1975; Rowe, 1981).

2. The breeding plan developed was essentially simple: first, breed good, disease-resistant and pollen-fertile diploids (AA) and then cross them onto the semi-dwarf mutant ('Highgate') of 'Gros Michel'. Very few seeds are obtained (about one per bunch) but those few yield a small proportion of tetraploids ((AAA) + A = AAAA — see Figure 3) which are potentially commercial. The best are very good indeed, not too tall, vigorous, productive and disease-resistant, but often of dubious shipping quality. The key to commercial breeding lies in effective diploid improvement: hence the crucial importance of good collections of wild *acuminata* and edible diploid cultivars.

3. Dwarfness is important because tetraploids out of full-sized triploids are generally too big. By good luck, the dwarf mutation of 'Gros Michel' is semi-dominant, so the AAAA progeny are a good, middling size. We may reasonably assume that the same genetical principle will hold elsewhere, so a food-crop breeding programme will need dwarf mutants for parents.

4. New triploids can be made from the cross (A)A x (AA)AA but have so far not proved commercially attractive, though admittedly not yet widely explored.

5. The importance of good collections will be evident (IBPGR, 1978). The best are held in Jamaica and Honduras and there are less extensive ones in Brazil, West Africa, Indonesia and the Philippines. The Philippine collection is being built up as a major international centre (IBPGR, 1978 1983). For commercial breeding, the AA bananas, wild and cultivated, are crucial; for food-crop breeding, the range of female clones must be much wider but the synthetic AA male parents remain critical (see below).

b. Food crop breeding

1. Local tastes in bananas vary widely. People prefer what they are accustomed to and are usually unwilling to change. The object of food-crop breeding must be to produce a wide range of clones, having diverse field and quality characters, that can be adapted to local circumstances. We need not assume that preferences are immutable: under, say, disease stress, new clones may be essential if bananas are to be grown at all. There is plenty of experience to say that tastes can change if they must change.

2. There is no direct experience of food-crop breeding because no one has ever tried, but we know the following: (a) most edible bananas will give at least a few seeds if pollinated and their progeny are roughly predictable as to genome constitution (Figure 4); (b) the plantains are known to produce occasional progeny (Rowe, 1981); (c) given the wide range of fruit qualities required, the possible crosses to be explored are very numerous and the useful outcomes might be either triploid or tetraploid (anyway, probably not diploid) (Figure 4); (d) disease-resistant AA male

parents remain important in any programme (excellent ones already exist) but there will be need also of wider exploration of B genomes; (e) dwarfness will have to be used in many crosses to avoid the production of over-sized tetraploids.

3. The objectives of a food-crop programme must be rather widely, perhaps even loosely, stated until enough experience accumulates to permit more precise definition. They will include: (a) yield (though not necessarily on a pure-stand t/ha basis); (b) aptitude for shade-nurse-inter-cropping use; (c) diverse fruit qualities, from sweet to acid-starchy; (d) diverse disease resistances, though not (to be realistic!) all assembled in one clone.

4. The diseases to be considered include: Panama disease (banana wilt), Moko disease (Bacterial wilt), Sigatoka disease (Leaf spot), Black Sigatoka (Black leaf streak), Burrowing nematodes and Bunchy top virus. We know something about resistances but not yet nearly enough. We must assume, I think, that expensive chemical control measures against diseases will generally be irrelevant for small farmers. At this moment it looks as though peculiar threats are posed by: Black Sigatoka, which has recently become established in West Africa and Central America and is certain to spread; and Bunch top, widely spread in South-East Asia, India and West Africa but not in the Americas; its status is ambiguous but it is potentially very damaging .

5. There is a vital technical adjunct to any international food-crop breeding programme, namely, shoot-tip (meristem) culture. The technique is quite simple and already well proven. It will be very useful for multiplication of new clones and extremely useful, even critical, for the

international dissemination of clones through plant quarantine systems. Since the sensible first step is any banana food-crop programme must be the wide dissemination of the many useful bananas that are not already generally dispersed, the practical importance of shoot-tip culture can hardly be over-emphasised.

4. SUMMARY

1. The cultivated bananas are derived from two wild species native to South-East Asia: *Musa acuminata* (AA) and *M. balbisiana* (BB). Parthenocarpy and seed-sterility, evolved under human selection, jointly constitute edibility. The edible bananas evolved in South-East Asia from edible diploid (AA) progenitors and spread thence throughout the tropics to the moister areas between 30^{o} North and South.

2. Bananas constitute a hybrid-polyploid complex and are classified by genome constitution thus: AA, AAA, AAAA, AB, AAB, AAAB, AABB, ABBB. Broadly, *balbisiana* (B) genomes confer hardiness, disease resistance and acid-starchy fruit quality.

3. The scientific bases of commercial banana breeding, aimed at export clones, are fairly well understood, though neither of the two major programmes has been successful. Fairly good collections are available and excellent diploid male parents (AA) have been synthesized.

4. The established scientific principles can be carried over into food-crop breeding programmes, with much broader objectives and genetically much more diverse outputs of potentially useful varieties, all polyploid and mostly hybrid. Shoot-tip culture, already a well-established technique, will be of great value for multiplication and dissemination of clones, both existing ones and newly-bred ones, in due course.

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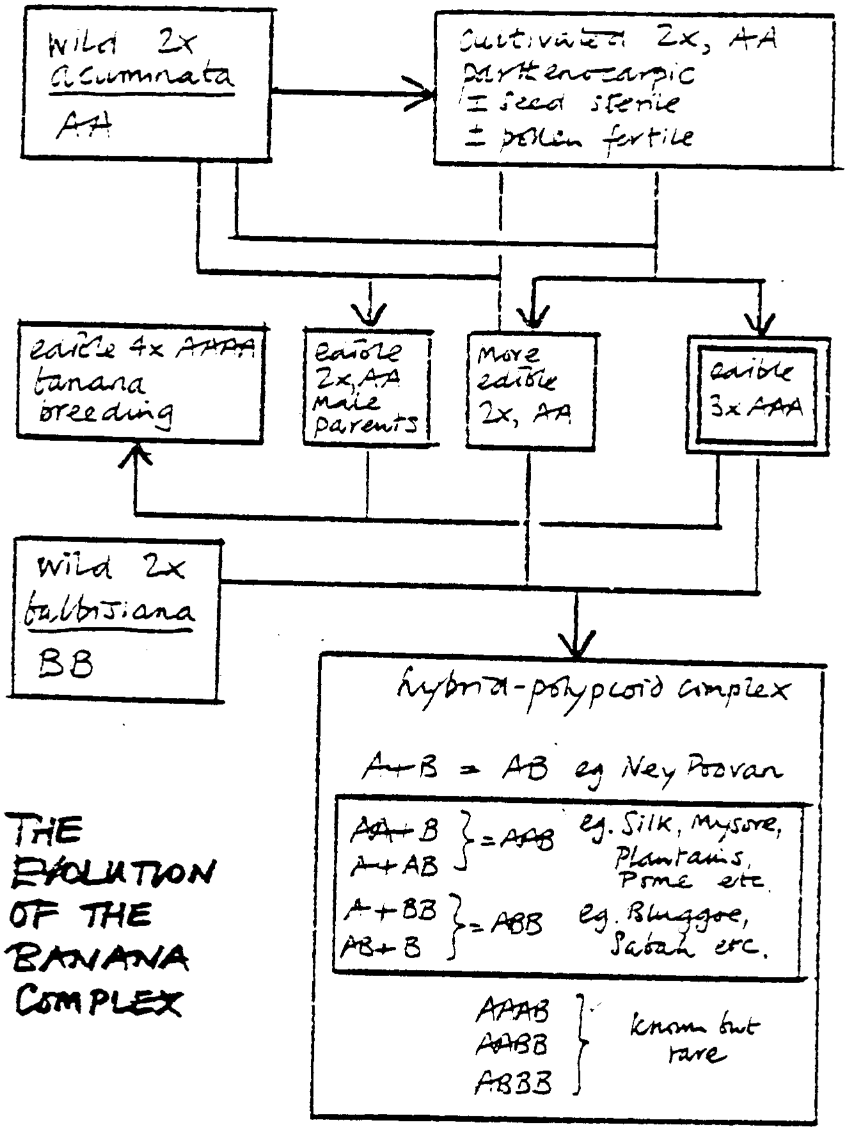
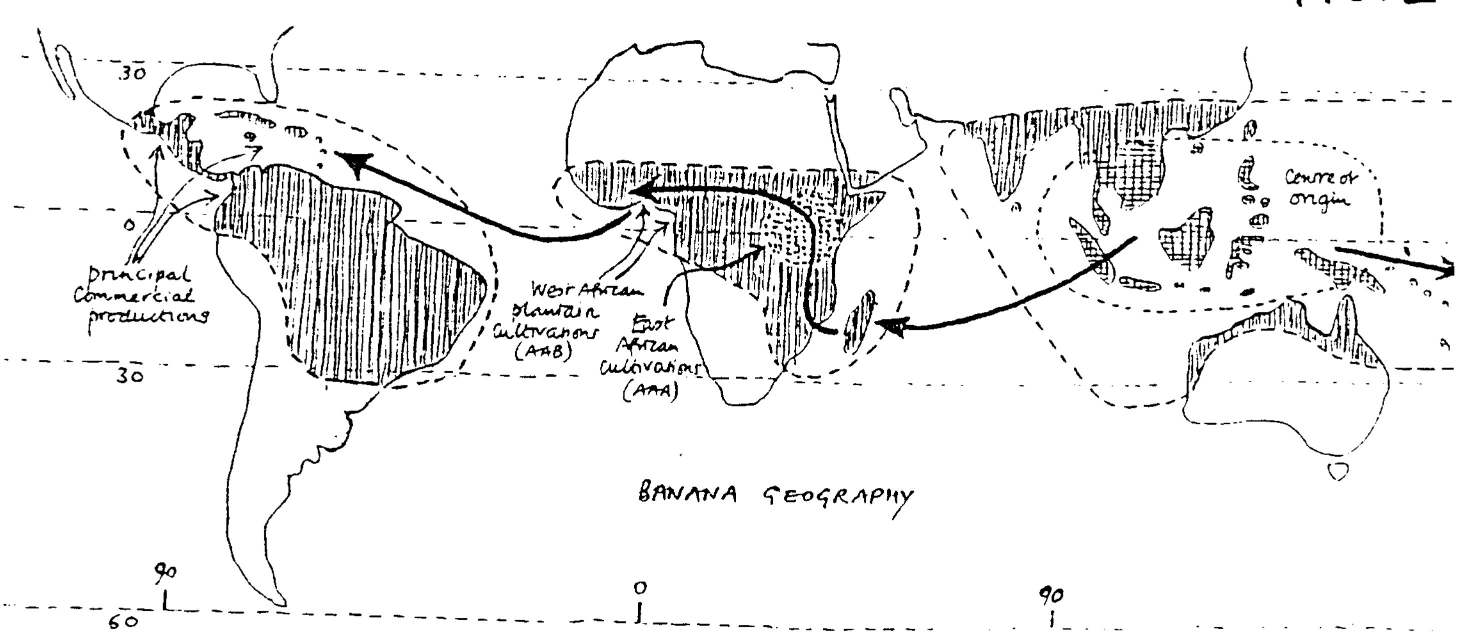

Wild 2x
Acuminata
AA
Cultivated 2x, AA
parthenocarpic
± seed sterile
± pollen fertile
edible 4x AAAA
banana
breeding
edible
2x, AA
male
parents
More
edible
2x, AA
edible
3x AAA
Wild 2x
balbisiana
BB
hybrid-polyploid complex
A+B = AB eg Ney Poovan
AA+B
A+AB
= AAB eg. Silk, Mysore, Plantains, Pome etc
A+BB
AB+B
= ABB eg. Bluggoe, Saban etc.
AAAB
AABB
ABBB
known but rare
THE EVOLUTION OF THE BANANA COMPLEX

FIG. 1

FIG. 2


30
0
30
Principal Commercial productions
West African plantain cultivations (AAB)
East African cultivations (AAA)
Centre of origin
BANANA GEOGRAPHY
90
60
0
90

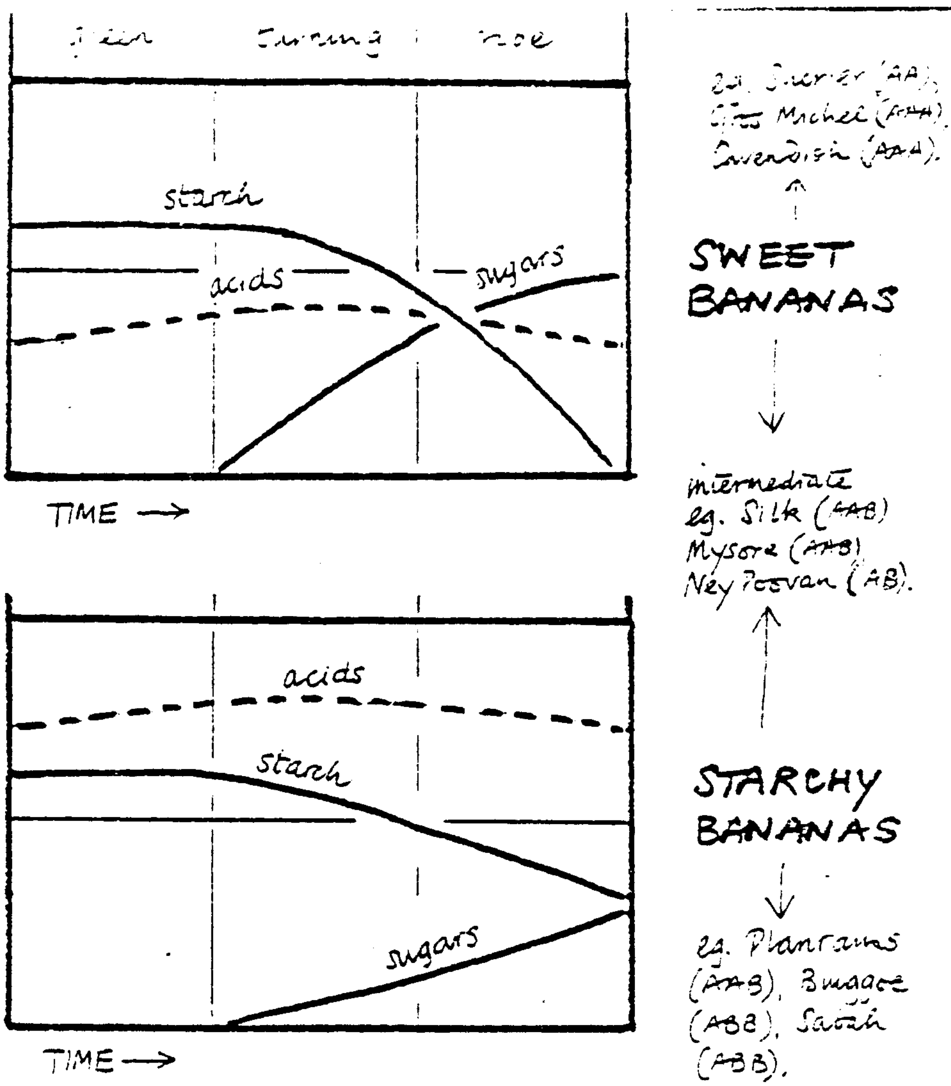


FIG. 3

BANANA FOOD CROP BREEDING COMBINATIONS

Constitution	Sources
AAA	(AA)[2] × (A)A, (AA)AA × (A)A
AAAA	(AAA)[2] ×[1] (A)A, (AA)AA × (AA)AA
AAB	(AA)[2] × (B)B, A(AB) × (A)A, A(AA)B × (A)A
ABB	(BB)[2] × (A)A, A(AB)B × (B)B, (BB)BB × (A)A
AAAB	(AAB)[2] × (A)A, (AAA)[2] × (B)B, A(AB)B × (AA)AA
AABB	(AA)AA × (BB)BB, A(BA)B × A(BA)B, (AAB)[2] × (B)B
ABBB	A(AB)B × (BB)BB, (ABB)[2] × (B)B

FIG. 4

Notes: 1) The basic commercial banana breeding cross, the only well explored combination.
2) Restitution, male or female, implied

TABLE 3.1

CHARACTERS USED IN TAXONOMIC SCORING OF BANANA CULTIVARS (from Simmonds and Shepherd, 1955)

CHARACTER	*M. acuminata*	*M. balbisiana*
Pseudostem colour	More or less heavily marked with brown or black blotches	Blotches slight or absent
Petiolar canal	Margin erect or spreading, with scarious wings below, not clasping pseudostem	Margin inclosed, not winged below, clasping pseudostem
Peduncle	Usually downy or hairy	Glabrous
Pedicels	Short	Long
Ovules	Two regular rows in each loculus (Fig. 3.2)	Four irregular rows in each loculus (Fig. 3.2)
Bract shoulder	Usually high (ratio $<0{\cdot}28$ —Fig. 3.2)	Usually low (ratio $> 0{\cdot}30$ —Fig. 3·2)
Bract curling*	Bracts reflex and roll back after opening (Fig. 3.2)	Bracts lift but do not roll (Fig. 3.2)
Bract shape	Lanceolate or narrowly ovate, tapering sharply from the shoulder (Fig. 3.2)	Broadly ovate, not tapering sharply (Fig. 3.2)
Bract apex	Acute (Fig. 3.2)	Obtuse (Fig. 3.2)
Bract colour	Red, dull purple or yellow outside; pink, dull purple or yellow inside	Distinctive brownish-purple outside; bright crimson inside
Colour fading	Inside bract colour fades to yellow towards the base	Inside bract colour continuous to base
Bract scars	Prominent (Fig. 3.2)	Scarcely prominent (Fig. 3.2)
Free tepal of male flower	Variably corrugated below tip (Fig. 3.2)	Rarely corrugated (Fig. 3.2)
Male flower colour	Creamy white	Variably flushed with pink
Stigma colour	Orange or rich yellow	Cream, pale yellow or pale pink

* In varieties with persistent male bracts, curling is weak or absent, regardless of genotype.

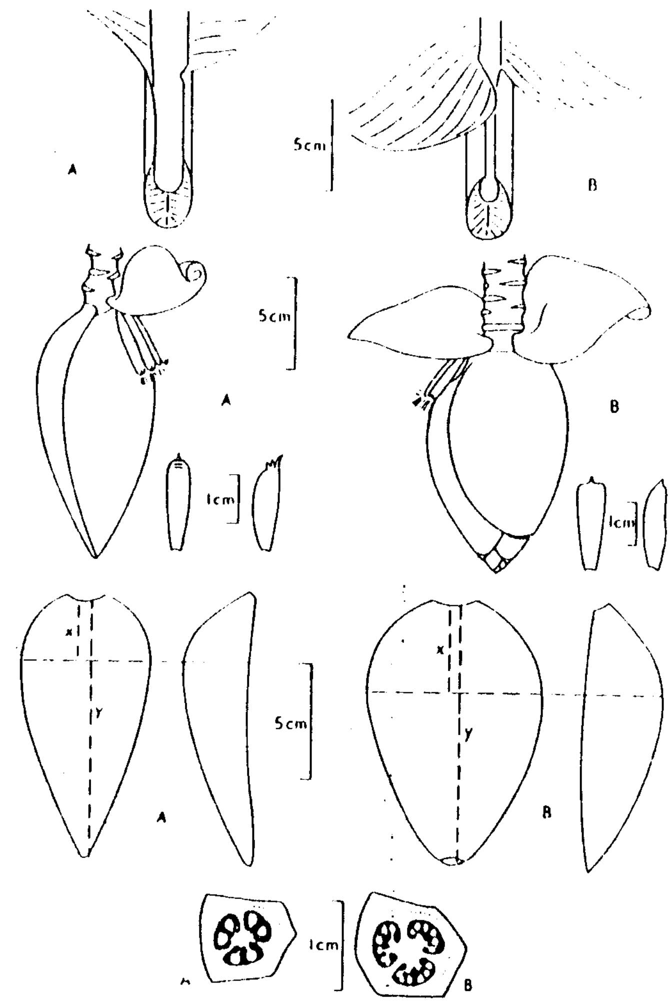


FIG. 3.2
TO ILLUSTRATE TABLE 3.1

M. acuminata (A) on left, *M. balbisiana* (B) on right. From top to bottom: petioles, male buds (to show shape, bract curling and bract insertion), free tepals of male flowers, male bracts (ratio x/y) and ovule arrangement (note also the different ovule sizes). Redrawn (somewhat modified and expanded) from Simmonds and Shepherd (1955)

CURRENT INPUTS TO BANANA AND PLANTAIN RESEARCH

Data on the scientific manpower and funds devoted to banana and plantain research are difficult to come by, although FAO is currently preparing an inventory on this topic.

The information on the following pages has been provided by FAO, IITA, ACIAR and IDRC, and is provisional and probably subject to sizeable error particularly with respect to duplication between national and donor contributions. It also does not differentiate between research and disease control (spraying) in some countries.

The largest on-going programmes appear to be:

IRFA	- in mainland France, Guadeloupe, Martinique, Cameroon, Gabon, Ivory Coast, Senegal and Upper Volta
WINBAN	- supported by a producer cess and EEC, ODA, CIDA, IDRC and CFTA
BRAZIL	- national programme
HONDURAS	- now national with FAO support, formerly United Brands
NIGERIA	- national program
IVORY COAST	- national program and IRFA
IITA	- core and IFAD funding

Overall the total figure for research funding appears unlikely to be greather than US$6 million per annum (of which nearly a third is IRFA), and the number of scientists involved (including many part-time) seems unlikely to exceed 400. However, these figure can only be regarded as first estimates until more reliable information is available.

BANANA AND PLANTAIN RESEARCH [1/]

	Number of Scientists	Annual Expenditure US$000	Notes
CENTRAL AFRICA			
Cameroons	2*	330	Some IRFA & IDRC support
Gabon	1*	320	Some IRFA support
Zaire		15	
		(700) [2/]	
EAST AFRICA			
Burundi	0.1	?	
Kenya	1.5	30	
Tanzania	1	20	Possible EEC project
IRAZ		?	Possible $1 m + FAO project
Uganda	0.7	8	Possible IDRC project
Malawi	0.7	12	
Zimbabwe	0.1	1	
		(100)	
WEST AFRICA			
Ghana		22	
Ivory Coast	4+4*	450	IRFA support
Nigeria		300	
IITA		500	Some IFAD & Belgium support
Senegal	1*	80	IRFA support
Upper Volta	1*	80	IRFA support
		(1400)	
LATIN AMERICA			
Brazil	80	600	
Colombia	50	300	
Costa Rica	14	45	
Ecuador	12	240	
Guatemala	7	?	By-product research
Honduras	16	500(1983)	United Fruit Company

cont'd..

	Number of Scientists	Annual Expenditure US$000	Notes
LATIN AMERICA cont'd.			
Jamaica	8	200	IDRC project $47,000
Mexico	12	124	
St. Lucia (WINBAN)	20	1056	Of which $666,000 from donors (IDRC,ODA, ED
CATIE		66	IDRC project
UPEB		?	IDRC project
		(3100)	
OTHERS			
France (IRFA)	27	1100	Includes Guadeloupe & Martinique
Israel	3	40	
Spain	1	5	
Belgium (Louvain		?	
Germany (Gottingham)		?	
		(1200)	
ASIA/OCEANIA			
Australia	19	137	
Indonesia		?25	
Malaysia			
PNG			
Philippines			80 from IDRC
Thailand			
		(300)	
Grand Total	(400)	(6800)	

* Are out-posted French scientists from IRFA.

1/ In some cases a significant part of the funding is used for disease control rather than research.

2/ Figures in brackets are approximations.

A NOTE ON RECENT REGIONAL CONSULTATIONS ON BANANA RESEARCH AND THE ROLE OF AN INTERNATIONAL NETWORK

At the donor meeting in Washington on November 1, 1983, IDRC was asked, in the furtherance of a dialogue on a proposed banana and plantain research network, to consult with banana and plantain producing countries. This note summarizes the activities which have taken place in this respect (see also Appendix 8).

WEST AFRICA

The fourth annual meeting of the West African Regional Cooperative for Research on Plaintain (WARCORP) took place at IITA from December 5-8, 1983. It was attended by representatives of a number of West African countries who reviewed 14 on-going projects funded by WARCORP in Ivory Coast, Ghana, Nigeria, Zaire, Cameroon and Gabon. The coordinator recorded the establishment of a tissue culture laboratory for research and training in banana/plantain multiplication at Onne and reported on a tissue culture training course held in February 1983, and a production training course in October of that year. He also mentioned that the TAC QQR of IITA had suggested that plantain should become a core mandate crop of IITA and had also commended the organization and activities of WARCORP.

The meeting was given a summary report of the donor group meeting in Washington on November 1. It discussed at length the proposal for an international network with a strong breeding component and pledged its strong support for this concept. A proposal that WARCORP should be expanded to be a Pan-African network covering cooking bananas as well as plantains was unanimously accepted.

EAST AFRICA

A regional workshop on banana and plantain production in Eastern and Central Africa sponsored by IDRC took place in Burundi from December 14-17, 1983. It was attended by 17 representatives from Burundi, Rwanda, Kenya, Uganda, Tanzania, Zaire and IRAZ, and by scientists from Belgium, the U.K., IITA and IDRC.

The workshop discussions stressed the need for establishing small local working collections of germ plasm backed up by a well maintained and accessible regional collection and an international breeding program responsive to users interests. It particularly noted the importance of black sigatoka in this respect and also recognized the significance of meristem culture work in the introduction of disease-free material. The workshop, whose report will be published by IDRC, was briefed on the November meeting in Washington. It strongly endorsed the WARCORP network approach and recommended that funds should be sought for establishing a similar network for Eastern and Central Africa. It suggested that if donor support was forthcoming for a recent proposal for strengthening banana and plantain research at IRAZ, this institution could serve as an appropriate base location for the regional network.

SOUTH EAST ASIA, PAPUA NEW GUINEA AND THE SOUTH PACIFIC

A consultant from ACIAR visited the Philippines, Thailand, Malaysia, Indonesia and Papua New Guinea in February and March 1984. His terms of reference were to gather information and report on the importance and distribution of bananas (both dessert and cooking) in these countries; to determine constraints to their production; to report on research being undertaken on bananas; to gather information on regional germ plasm collections; and to ascertain national reactions to the formation of an international research network. A staff member of ACIAR prepared a parallel report on the South Pacific based on past knowledge and current visits to selected territories and three recent ISNAR reports (South Pacific, Fiji and Western Samoa).

The two ACIAR reports provide considerable background information. They indicate that there are a number of workable collections in the region but little on-going research and quite limited knowledge of research priorities, although in a number of the countries bananas are an important crop. Disease appears to be a major constraint and in some exporting countries post-harvest losses are also important.

There is considerable interest in germ plasm exchange although reservations were expressed as to whether quarantine authorities would accept imports of material propagated by tissue culture and as to whether some countries would freely permit export of germ plasm. The need for a strong breeding program was recognized, although the disappointing past results in breeding were also commented on. It was emphasized that breeding should be consumer oriented and should stress cooking bananas rather than export dessert types.

Interest in a network was largely regional in outlook, especially amongst the ASEAN countries. In more than one country there were criticisms of networks on the grounds that there were too many of them and that they did little other than hold meetings and write reports. There was, however, a strong interest in obtaining greater donor inputs for strengthening research activities with bananas.

LATIN AMERICA AND THE CARIBBEAN

In the Caribbean and Latin America, an informal network already exists in the Association for Cooperation in Banana Research in the Caribbean and Tropical America (ACORBAT), which was established by the Universities of the West Indies and Puerto Rico, the Governments of Trinidad and Jamaica, and IRFA, as long ago as 1964. At its 1983 meeting in Guadeloupe, ACORBAT's managing committee were urged to seek funds for strengthening the network and for expanding research on bananas. At a regional consultation held on April 30 and May 1, 1984 in Miami, Florida, members of ACORBAT's committee expressed the views that the proposed global network was entirely consistent with this goal; particularly if ACORBAT were to play a regional role analogous to that played by WARCORP in Africa. In this context the Latin American and Caribbean group suggested that CATIE (if agreeable) would be the logical base for the regional coordinator to operate from.

In supporting the need for the network, the Latin American consultation laid great stress on the economic justification for giving greater emphasis to breeding as a tool for disease control. It pointed out, for example, that the use of chemicals for the control of black sigatoka in exporting areas was of the order of US$1,000 per ha per annum and represented 24% of the cost of production - a cash cost that most small producers could not carry.

The meeting reviewed a draft of the Rome paper and offered a number of detailed suggestions which have been incorporated in the attached revision of the paper. In particular it stressed the need for the national evaluation of existing germ plasm in order to determine existing biological variability; the importance of at least one, if not more, strong breeding programs; the potential role of tissue culture in the exchange of material; the need for greater awareness of what germ plasm was available and what research was being carried out in other countries; the importance of a comprehensive documentation and information system especially with respect to non-conventional material; the desirability of a good regional training program for banana research workers and the care that would need to be exercised in the selection of the coordinators in order to ensure the success of the network. These observations were offered against a background of strong and positive support for the approach put forward in this paper.

RECENT DOCUMENTATION RELEVANT TO A BANANA RESEARCH NETWORK

Brown, J.F. (1984) Bananas in South East Asia and Papua New Guinea, a report to ACIAR (mimeo draft unpaginated - contact Dr. G. Persley)

DeLanghe, E.A.L. (1983) Report of a consultant mission to IRAZ (Burundi, Rwanda, Zaire) regarding banana research, FAO Rome (in French - mimeo 112 pp - contact Dr. J. Monyo, FAO Rome)

Edmunds, J.E. (1983) Banana Research in the Windward Islands - Paper presented at the UNECLA Workshop on Agricultural Research Policy and Management (in the Caribbean), Trinidad, September 26-30, 1983. Mimeo 16 pp (contact Dr. J.E. Edmunds now at UWI Trinidad)

IDRC, (1984) Report of a consultation on Banana Research in Latin America and the Caribbean held in Miami, U.S.A. on April 30 and May 1, 1984 (in press - contact Dr. N. Mateo, IDRC Bogota)

IDRC, (1984) Report of a Workshop on Banana Production and Research in Central and East Africa held in Bujumbura, Burundi, December 14-17, 1983 (in press - contact Dr. R. Kirkby, IDRC Nairobi)

IITA, (1981) Report to IFAD for Support of a Special Project on Research Aimed at Developing Methods for Increasing Plantain Production in the Humid Tropics of Africa

IITA, (1983) Report to IFAD for Support of Phase II of a Special Project on Research Aimed at Developing Methods of Increasing Plantain Production in the Humid Tropics of Africa

IRFA, (1983) Report of the second meeting of the International Association for Research on Plantains and Cooking Bananas (IARPCB) held at Ibadan July, 1981 in Fruits 38:4:219-354 (in French - the original English version is available from IARPCB c/o Dr. G. Wilson, IITA)

Persley G.J. (1984) Banana Production in the South Pacific, a draft report (mimeo - 34 pp - contact Dr. G. Persley, ACIAR)

UNECLA, (1983) Workshop on Agricultural Research Policy & Management (in the Caribbean) Trinidad, September 26-30, 1983, Appendix II Draft Report of the Working Group on Banana, mimeo 9 pp

WARCORP, (1984) Report of the Fourth Annual Meeting of the West African Regional Cooperative for Research on Plantain, IITA, Ibadan December 5-8, 1983 (contact Dr. G. Wilson, IITA)